ADOT

Intermodal Transportation

SOILS & AGG TECHNICIAN REVIEW TRAINING

Study Guide

January 2016

ADOT SOILS AND AGGREGATE REVIEW CLASS SCHEDULE

Day 1

PREFACE

ADOT WEB Site for Test Methods: http://www.azdot.gov/Highways/Materials/QA/QA_Manuals/index.asp
SAFTEY
ROUNDING PROCEDURE

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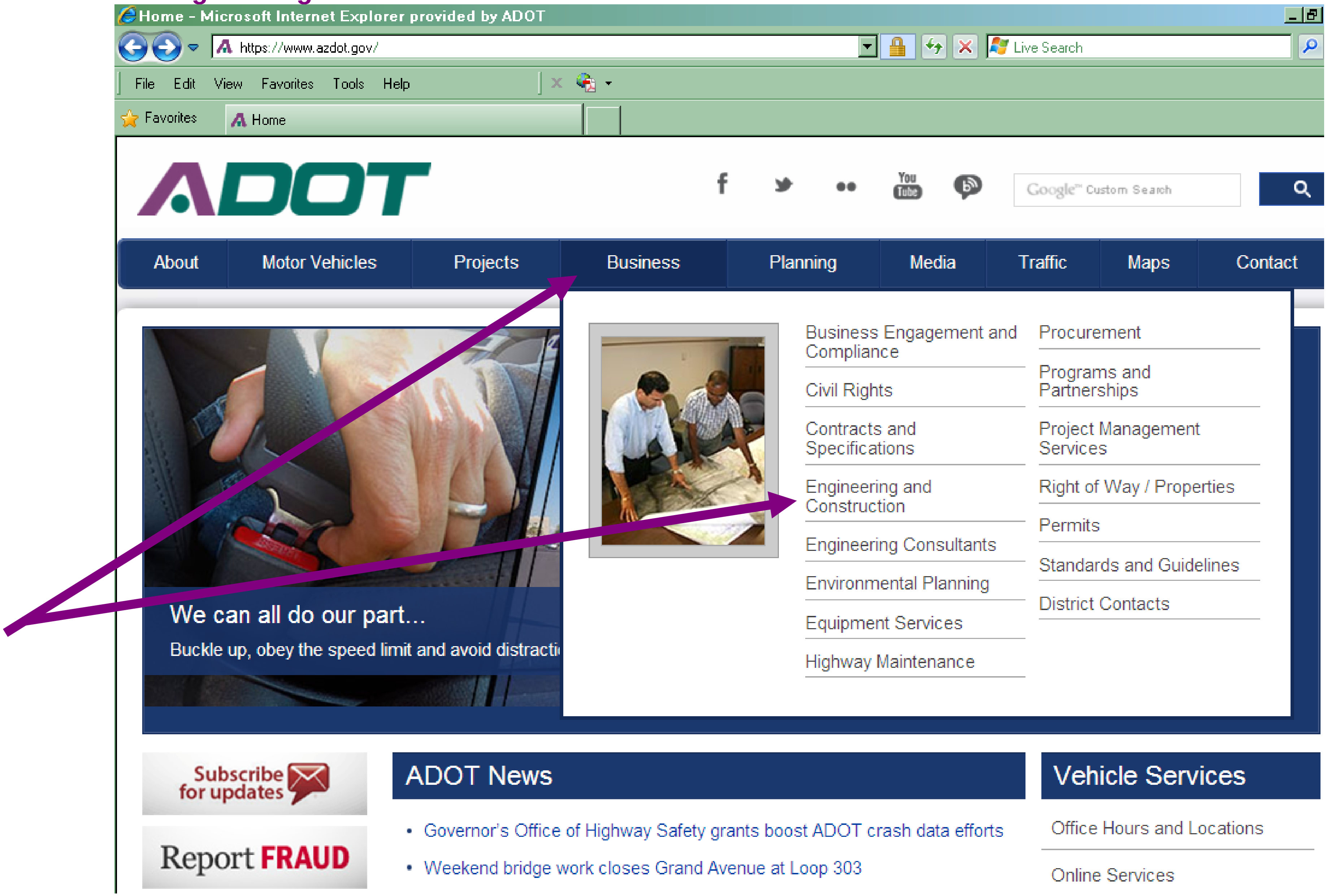
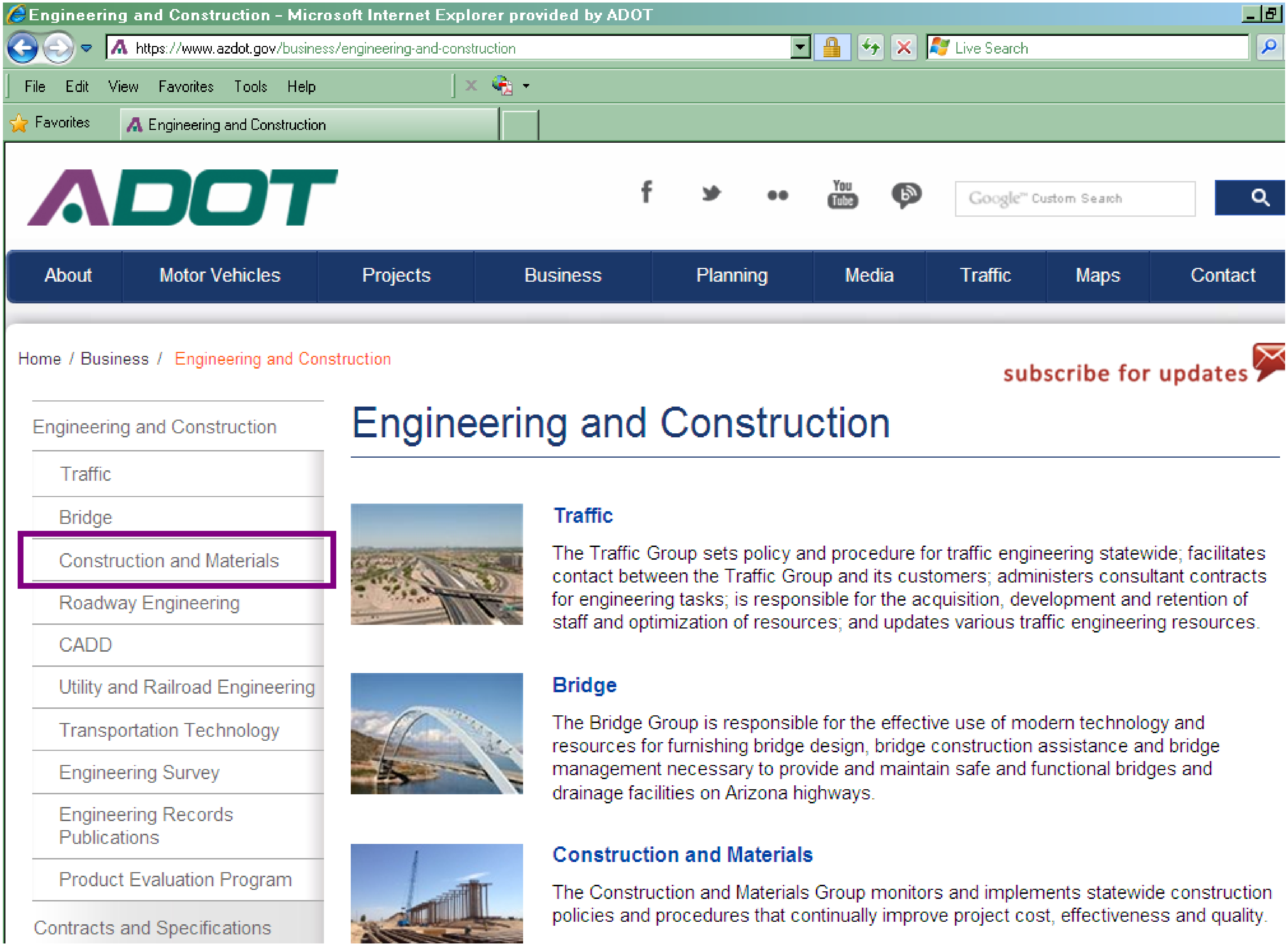
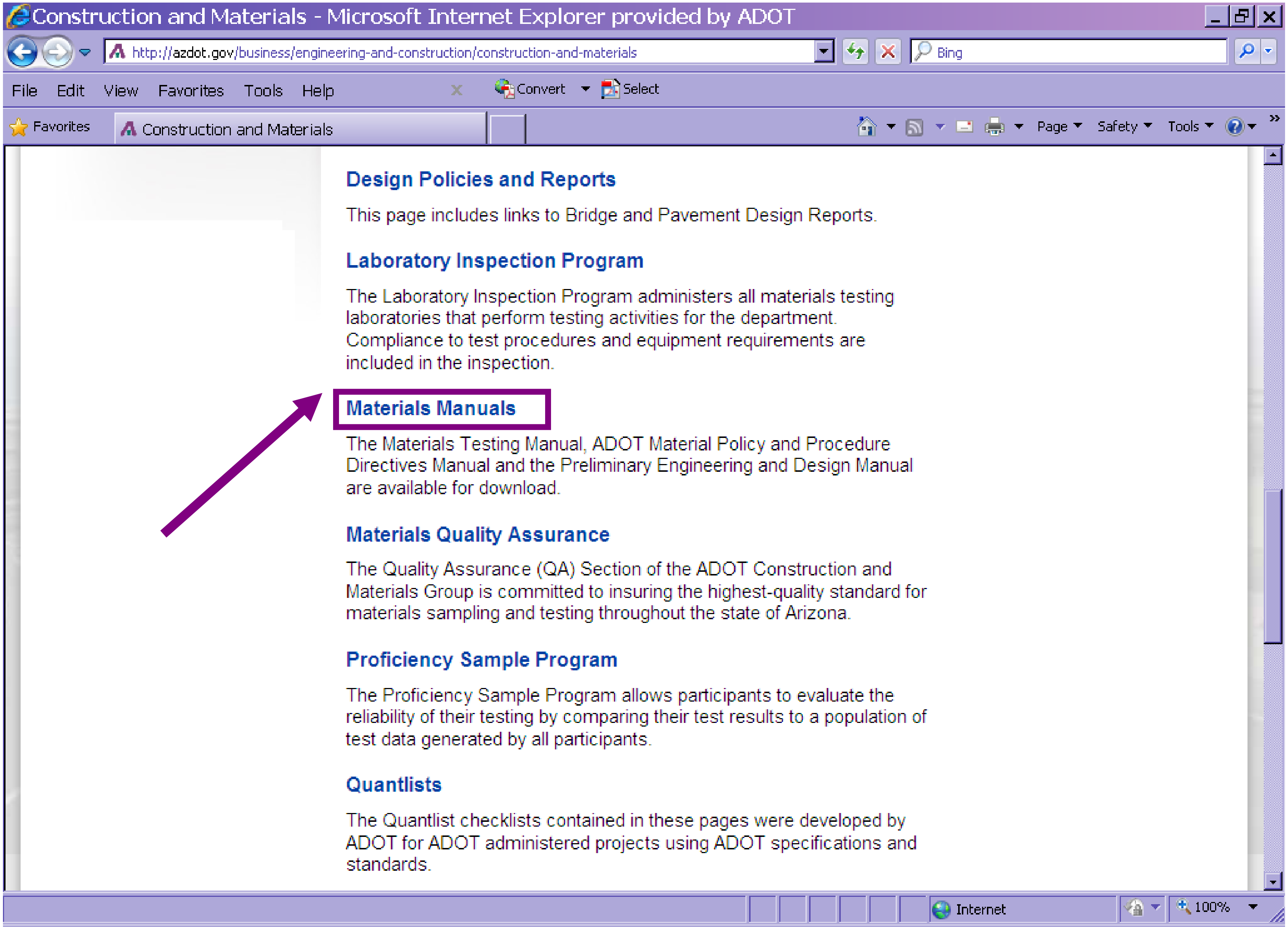
ADOT Website, to retrieve any ADOT Test Methods, select the following link;
http://azdot.gov/business/engineering-and-construction/construction-and-materials
Select **Engineering and Construction** under Business.



Select Construction and Materials



Scroll down until you See Materials Manuals then select it.



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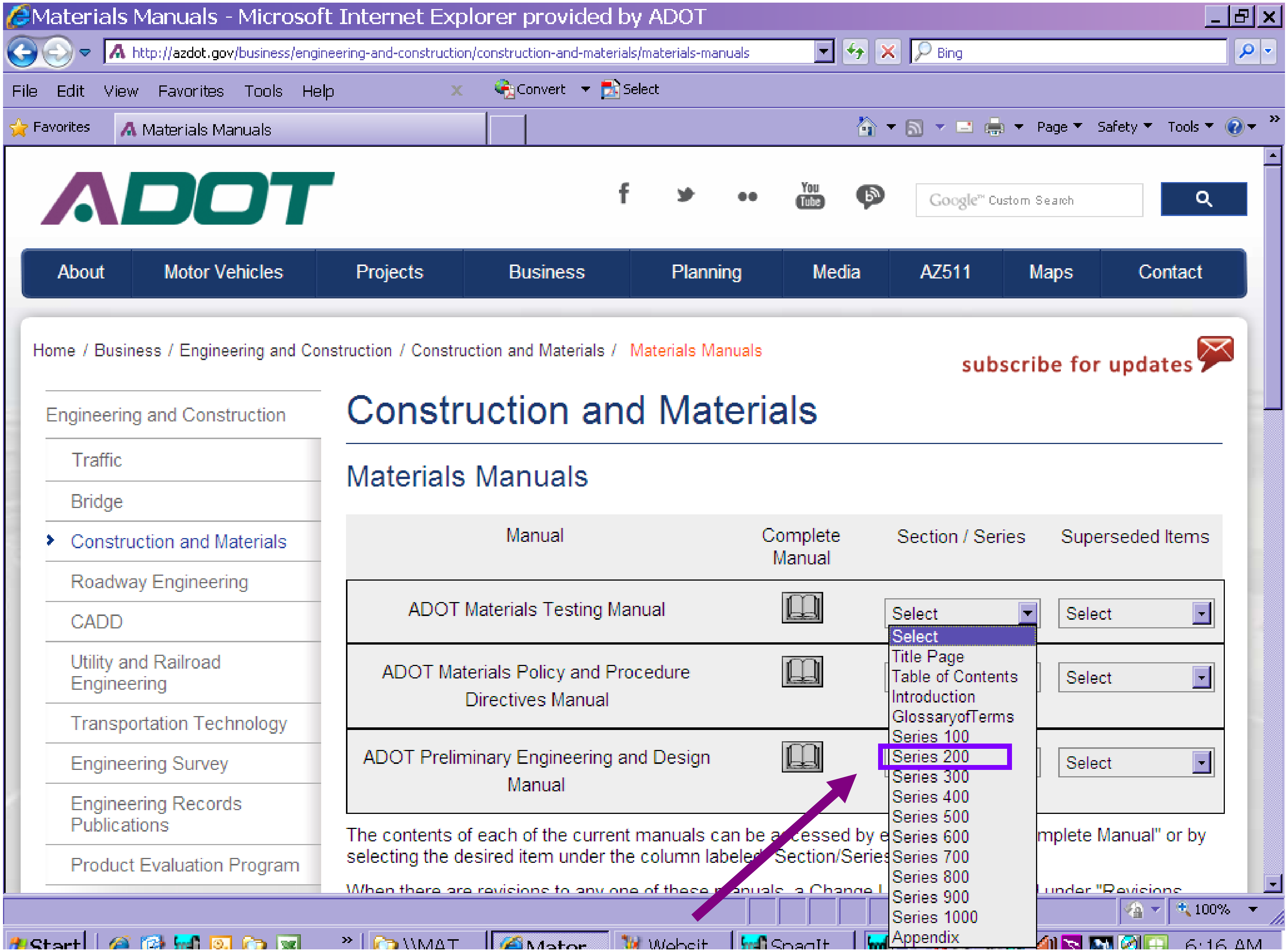
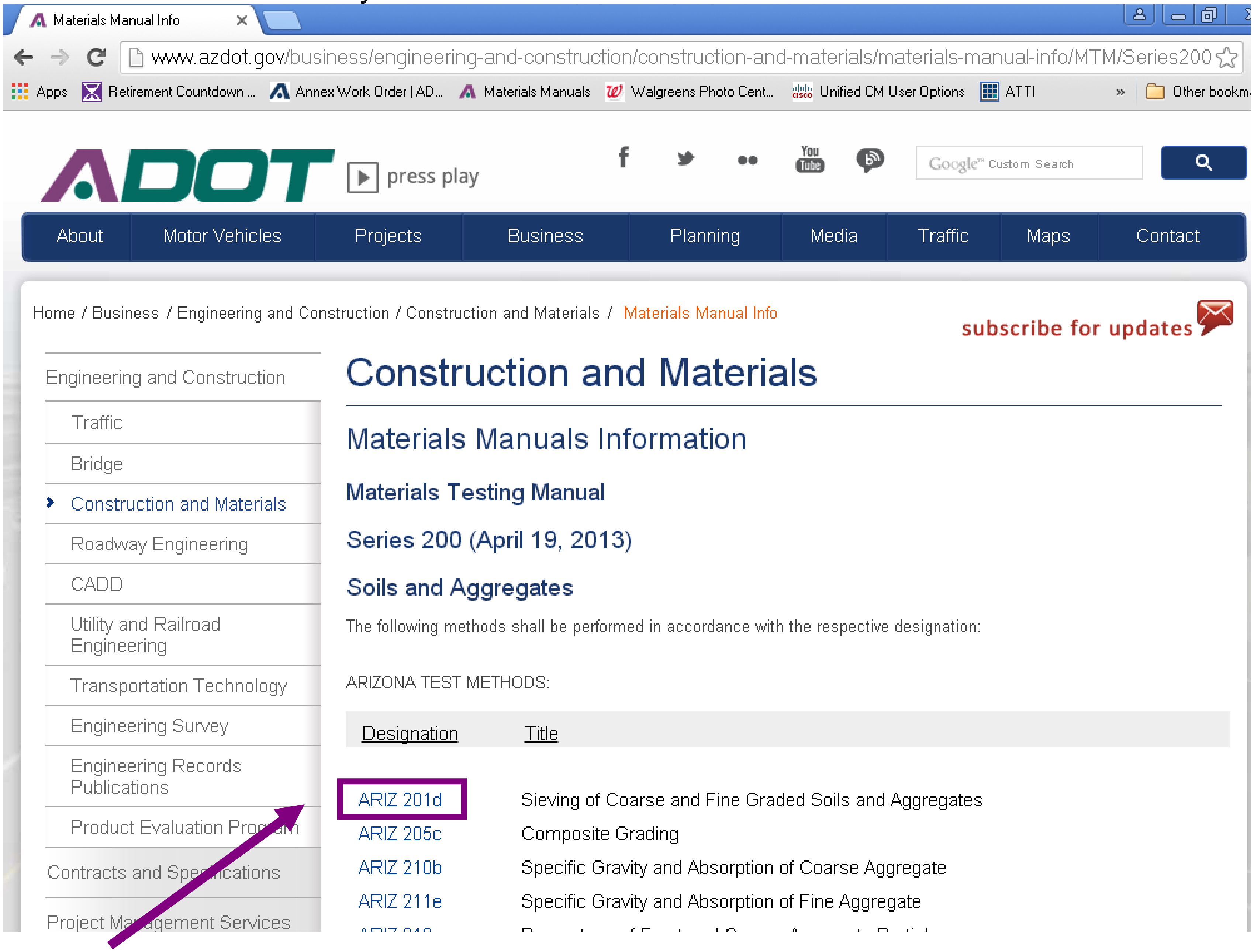


Then choose the Test Method you wish to retrieve.



You can now print or save the Test Method

SAFETY

Some of the test methods in this manual may involve hazardous materials operations, and/or equipment. This manual does not claim to address all relevant safety issues which may be encountered or which may be associated with its use or with the performance of test procedures introduced here. It is the responsibility of the technician to determine, establish, and follow appropriate health and safety practices. The technician must also determine the applicability of any regulatory limitations of test equipment and chemicals. (Page 3 of blue workbook)

ROUNDING PROCEDURE

The following describes the rounding procedure which is to be used for rounding numbers to the required degree of accuracy:

1. Except as specified in Section 2 below, the following procedure will apply. This procedure correlates with the "built-in" rounding method normally utilized by calculators and computers.

1.1 When the figure next beyond the last figure or place to be retained is less than 5, the figure in the last place retained is left unchanged.

Examples:
Rounding 2.6324 to the nearest thousandth is 2.632
Rounding 7843.343 to the nearest hundredth is 7843.34
Rounding 4928.22 to the nearest tenth is 4928.2
Rounding 7293.1 to the nearest whole number is 7293
Rounding 2042 to the nearest units of 10 is 2040
Rounding 3548 to the nearest units of 100 is 3500
Rounding 8436 to the nearest units of 1000 is 8000

1.2 When the figure next beyond the last figure or place to be retained is 5 or larger, the figure in the last place retained is increased by 1.

Examples:
Rounding 4839.4575 to the nearest thousandth is 4839.458
Rounding 9347.215 to the nearest hundredth is 9347.22
Rounding 8420.35 to the nearest tenth is 8420.4
Rounding 1728.5 to the nearest whole number is 1729
Rounding 3685 to the nearest units of 10 is 3690
Rounding 6650 to the nearest units of 100 is 6700
Rounding 2500 to the nearest units of 1000 is 3000

Rounding 2.6326 to the nearest thousandth is 2.633
Rounding 7843.347 to the nearest hundredth is 7843.35
Rounding 4928.28 to the nearest tenth is 4928.3
Rounding 7293.9 to the nearest whole number is 7294
Rounding 2046 to the nearest units of 10 is 2050
Rounding 3572 to the nearest units of 100 is 3600
Rounding 8634 to the nearest units of 1000 is 9000

1.3 No result shall be rounded more than once.

Example: 3024.5 rounded to the nearest units of 10 will be 3020;

not

3024.5 rounded to 3025, and then rounded again to 3030.

2. The rounding procedure specified in Section 1 above shall be used for all calculations and recording of data in performing materials testing, except when a specific test method cites a method of rounding which differs from this procedure, for example, the sand equivalent test (AASHTO T 176 or Arizona Test Method 242).

3. Compliance will be based upon interpreting the reported results as though they are rounded to the terms (whole numbers, decimals, or fractions reduced to decimals) of the specifications. For example, a value reported as 8.4% shall be considered as having no deviation from specifications that require 4 – 8%. It would however be a deviation for specifications requiring 4.0 – 8.0%.

4. Computers and most electronic calculators automatically carry several decimal places beyond the point of desired accuracy. At times, results of calculations utilizing these values are different than that achieved when calculations are performed utilizing values that have been rounded to the desired degree of accuracy by the above rules. The user is cautioned that the use of a computer or electronic calculator without re-entry of values after rounding, and discarding any figures beyond those needed, may cause unacceptable variations in final results.

Test Procedure Highlights

ARIZ 201d-15
Coarse and Fine Sieving

SAMPLE PREPARATION

1. Obtain a representative sample of the **amount indicated in the table** (Sec.3.2). **Dry** the sample to a **free-flowing** condition, and break up any **clods** in a manner that will **not reduce** the size of any rock. Sec. 3.1

2. **Weigh** and record the sample to at least the **nearest gram**. (Scale is readable to the nearest 1 gram). Sec. 2.4

COARSE SIEVING

1. Empty the sample into the nest of sieves that is to be used for screening material. Sec. 4.3

2. The material shall be **subjected to sieving** by hand or in a mechanical sieve shaker. Sec. 4.4

3. No particles shall be hand **manipulated** for passing any of the nested sieves. Sec. 4.4

4. Sieve long enough to assure "**thoroughness of sieving**" is achieved Sec. 4.4

5. **"Thoroughness of sieving"** is, not more than **0.5 percent** by weight of the **total** sample passes any sieve during **one minute** of continuous hand sieving. Sec. 4.5

6. Hold the sieve, with a snug fitting pan and cover, in a slightly inclined position in one hand. Strike the side of the sieve sharply and with an upward motion against the heel of the other hand at the rate of about **150 times per minute**, turn the sieve about **one-sixth** of a revolution at intervals of about **25 strokes**. Sec. 4.5

7. **Overloading** of sieves shall be avoided. The quantity of material on any sieve at the end of sieving shall not exceed the amount shown in the **table**. Sec. 4.6

8. Starting with the largest sieve, the material retained on each sieve and in the pan is **weighed and recorded** to at least the **nearest gram**. Sec. 4.7

ARIZ 201d-15
Coarse and Fine Sieving

9. If the difference between the sum of the total of the sieve weights (final weight) is **less than or equal to 1.0%** of the initial weight, **adjust** the largest weight retained, except no adjustments shall be made on the minus No. 4 material. If the difference is **greater than 1.0%**, the sample shall be recombined, **re-sieved**, and carefully reweighed. Sec. 4.8

SAMPLE FOR ELUTRIATION AND FINE SIEVING

1. A representative minimum **500 gram** sample of the passing No.4 material from the coarse sieving shall be obtained by the use of a splitter in accordance with AASHTO T 248. Sec. 5.1

2. The sample size may be **reduced** if 500 grams is not obtained from coarse sieving. Sec. 5.1

3. When utilizing the mechanical washing device, the 500 gram sample may be reduced to a minimum of **200 grams** for materials that tend to **clog the No. 200 sieve**. Sec. 5.1

4. The **weight** of the sample for elutriation and fine sieving is recorded to the **nearest gram** as "Dry Wt. Pass #4 Split". Sec. 5.2

MECHANICAL WASHING

1. Fill the washing device with water to the **bottom** of the windows and place sample into the device. Sec. 6.2

2. Utilizing the water tube, and air tube if necessary, **agitate** the sample vigorously enough so that it causes the material to go into **suspension**. Taking care that there is no loss of sample by **splattering or overflowing**. Sec. 6.2

3. Washing shall continue until the wash water becomes **clear**. Sec. 6.2

4. Wash the sample into a container large enough to hold the water and sample; allow the particles to settle and **decant** the excess water. Sec. 6.3

5. **Dry** the sample to constant weight at a temperature that will not cause the material to be lost due to splattering. Sec. 6.4

6. Allow the sample to cool, reweigh and record to the **nearest gram** as the fine sieve "Total Dry Weight". Sec. 6.5

ARIZ 201d-15
Coarse and Fine Sieving

HAND WASHING (REFEREE METHOD)

1. Place the sample in a pan large enough to wash without spillage. Cover with water to **thoroughly wash** aggregate. Agitate vigorously in order to **separate all minus No. 200** material from the coarser particles, and to bring the finer material into suspension so that it will be removed by decantation of the water. Sec. 7.1

2. **Decant** the wash water through a nest of **No. 16 and No. 200 sieves**. Sec. 7.2

3. **Repeat** the washing and decanting cycle until the water becomes **clear**. Sec. 7.3

4. **Thoroughly wash** all material remaining on **the No. 16 and the No. 200 sieves** and return to the sample. Sec. 7.4

5. After the particles have settled in the pan, carefully **decant** any excess water, assuring that no particles are lost. Sec. 7.5

6. Dry sample to constant weight at a temperature that will not cause material to be lost due to splattering. Sec. 7.6

7. Allow the sample to cool, reweigh and record to the **nearest gram** as the fine sieve "Total Dry Weight". Sec. 7.7

8. Subtract the “Total Dry Weight” from the “Dry Weight of Pass No. 4 Split and record as the “Elutriation”. Sec. 7.8

SIEVING OF FINE AGGREGATE

1. Empty the sample into the nest of sieves that is to be used for screening material. Sec. 8.1

2. The material shall be **subjected to sieving** by hand or in a mechanical sieve shaker. Sec. 8.2

3. No particles shall be hand **manipulated** for passing any of the nested sieves. Sec. 8.2

4. Sieve long enough to assure "**thoroughness of sieving**" is achieved described in Subsection 4.5. Sec. 8.2

ARIZ 201d-15
Coarse and Fine Sieving

5. **Overloading** of sieves shall be avoided. The quantity of material on a given sieve at the completion of sieving shall not exceed **4 grams per square inch** (**201 grams for an 8 inch** diameter sieve and **452 grams for a 12 inch** sieve). Sec. 8.3

6. Starting with the largest sieve, the material retained on each sieve and in the pan is **weighed and recorded** to at least the **nearest gram**. Sec. 8.4

7. If the difference between the sum of the total of the sieve weights (final weight) is **less than or equal to 1.0%** of the initial weight, **adjust** the largest weight retained, except no adjustments shall be made on the minus No. 200 material. If the difference is **greater than 1.0%**, the sample shall be recombined, **re-sieved**, and carefully reweighed. Sec. 8.5

8. The percent passing for each sieve in the coarse sieve analysis is determined. Record the sieve factor to at least six decimal places. The percent passing value for each sieve is recorded in the sieve analysis to the nearest whole percent. Sec. 10.2.2

9. Determine a factor for the fine sieve analysis by dividing the percent passing the No. 4 sieve (which has been recorded to the nearest whole percent) by the "Dry Weight of Pass #4 Split". Record the fine sieve factor to at least six decimal places. Sec. 10.3.1

10. **If all the pass No. 4 material from coarse sieving was subjected to elutriation and fine sieving, a fine sieve factor is not determined. Rather, the coarse sieve factor is utilized and the calculation of the percent passing each sieve is continuous through the entire sieve analysis.** Sec. 10.3.1

PERCENT PASSING
CALCULATION (ARIZ 201)

To calculate percent passing you will need a scientific calculator with at least one memory.

Always add up all the weights, **never change the amount in the total box**. If the calculated total is 1.0% or less from the total in the total box, adjust the number of the sieve weight with the largest amount retained except for the passing #4.

COARSE SIEVE

a. To get the Coarse sieve factor, divide 100 by the total weight of sample (the number in the total box).
b. Place the factor in the memory of the calculator (MR+).
c. Enter 100 in the calculator, subtract the first weight retained, times (x) the factor (memory recall) (MR),then the = key this will give you the % passing that sieve.
d: Keeping that number in the calculator subtract the next weight retained, multiply it by the factor (MR) until all % passing is calculated and recorded.
e. Continue this down to the #4 weight retained.
f. Then do a check on the pass #4 by, multiplying the weight passing the #4 times the factor (MR).

FINE SIEVE

Always add up all the weights, **never change the amount in the total box**. If the calculated total is 1.0% or less from the total in the total box, adjust the number of the sieve weight with the largest amount retained except for the passing #200.

a. Subtract the "Total Dry Weight" from the "Dry Wt. of -#4 Split" weight to get the elutriation weight and record it in the box provided.
b. To get the fine sieve factor, take the % passing the #4 (whole number) and divide it by the adjusted split weight. ***(If the minus #4 was not split, do not calculate a fine factor, use the coarse factor continuing down through the fine sieve analysis).***
c. Place the factor in the memory of the calculator.
d. Enter the % pass the #4 (whole number) in the calculator, subtract the weight retained on the #8 sieve, multiply, (x) it by the factor (MR) = to get the % passing the #8.
e. Keeping that number in the calculator subtract the next weight retained (#10), multiply (x) it by the factor (MR) until all % passing is calculated and recorded.
f. Continue this procedure down to the #200.
g. Do a check on the pass #200 by multiplying the (weight passing the 200 sieve plus + the elutriation weight) by the factor (MR).

When all the percent pass results are recorded, you may now record the percent retained for each sieve. Start with the largest % pass and subtract the next smaller % pass from it. Continue this down to the #200 sieve.

AASHTO T 11-05
Materials Finer than No. 200 Sieve in
Mineral Aggregate by Washing

PROCEDURE

1.	Obtain a representative sample and reduce in accordance with **AASHTO T 248**.	Sec. 6.2.
2.	The size of sample is determined from the **table in Para. 6.2.**	Sec. 6.2.
3.	**Dry** the sample to constant mass at **230 ± 9°F** and record weight to the **nearest 0.1 percent** of the total mass.	Sec. 8.1.
4.	Place the sample in a pan large enough to wash without spillage. Cover with water to **thoroughly wash** aggregate. **No detergent, dispersing agent or other substance is used for (Method A)**.	Sec. 8.3
5.	**Add detergent**, dispersing agent, or other substance wetting agent for (**Method B)**	Sec. 9.2.
6.	Agitate vigorously in order to **separate all minus No. 200** material from the coarser particles, and to bring the finer material into suspension.	Sec. 8.3./9.2
7.	**Immediately** pour the wash water through the nested sieves (**No. 8, No. 10, or No. 16 and a No. 200**). Avoid decanting coarser particles.	Sec. 8.3./9.2
8.	**Repeat** the washing and decanting cycle until the water becomes **clear**.	Sec. 8.4./9.3
9.	**Return** all material retained on the nested sieves by **flushing** to the washed sample.	Sec. 8.5.
10.	**Decant** any excess water through the **# 200 sieve**.	Sec. 8.5. Note 5
11.	**Dry** the sample to constant mass at **230 ± 9°F** and record weight to the **nearest 0.1 percent** of the total mass.	Sec. 8.5.
12.	Report the percent of minus No. 200 to the **nearest 0.1 %**, except if the result is **10 % or more**, then report the minus No. 200 to the nearest **whole number**.	Sec. 11.1.

ARIZ 210b-96
Specific Gravity and Absorption of Coarse Aggregate

SCOPE

1. This method covers the determination of specific gravity and absorption of coarse aggregate. The specific gravity may be expressed as bulk (O.D.) specific gravity, bulk (SSD) specific gravity [saturated surface dry], or apparent specific gravity. **This method is not intended to be used with lightweight aggregate**. Para. 1. (a)

2. The coarse specific gravity and absorption is normally determined on + No.4 material. When corresponding fine specific gravity and absorption are determined on -No.8 material in accordance with ARIZ 211, the coarse specific gravity and absorption shall be performed on + No.8 material**.** **"Coarse aggregate" as herein referenced will be for either plus + No.4 or + No.8 material**. Coarse specific gravity and absorption for other than asphaltic concrete friction course, shall be determined on + No.4 material". Para. 1. (b)

SAMPLING

1. Sample the aggregate in accordance with Arizona Test Method 105. Para. 3. (a)

2. A representative test sample of the plus **(No.4) or plus (No.8)** material with a minimum mass as shown in **the table** shall be obtained. Para. 3. (c)

PROCEDURE

1. Thoroughly **wash** the test sample to remove dust or other coatings from the surface. Para. 4. (a)

2. **Dry** the test sample to constant mass at a temperature of **230 ± 9 °F**. **Cool** in air at room temperature for **1 to 3 hours**. Para. 4. (b)

3. **Immerse** the aggregate in water at room temperature for a period of **15 to 19 hours**. Para. 4.(b)

4. Remove the test sample from the water and **roll** it in a large absorbent cloth until all visible films of water are removed from the surface of the aggregate, wiping the larger particles individually as necessary. Para. 4. (d)

ARIZ 210b-96
Specific Gravity and Absorption of Coarse Aggregate

5. **Immediately** determine the mass of the test sample in the saturated surface-dry (SSD) condition and record to **at least the nearest gram**. Para. 4. (d)

6. Immediately place the test sample in the sample basket container and determine its **mass in water at 73.4 ± 3.1 °F**. Para. 4. (e)

7. Take care to remove all **entrapped air** before determining the mass, by shaking the container while immersed. The container shall be immersed to a depth sufficient to **cover it** and the test sample during mass determination. Para. 4. (e)

8. After the balance has stabilized, determine and record the weight to at least the nearest gram. Para. 4. (e)

9. **Dry** the test sample to constant mass at a temperature of **230 ± 9 °F**. **Cool** in air at room temperature for **1 to 3 hours**. Weigh and record the weight to **at least the nearest gram**. Para. 4. (f)

REPORT

1. Report **specific gravity** results to the nearest **0.001 unit** and the **absorption** to the nearest **0.01%**. Para. 6. (a) (b)

ARIZ 211e-15
Specific Gravity and Absorption of Fine Aggregate

SCOPE

1. This method covers the determination of specific gravity and absorption of fine aggregate. The specific gravity may be expressed as bulk (O.D.) specific gravity, bulk saturated surface dry (SSD) specific gravity, or apparent specific gravity. Sec. 1.1

2. The fine specific gravity and absorption is normally done on -No.4 material. When the fine aggregate sample -No.4 contains a substantial amount of -No.4 to +No.8 material, such as in mineral aggregate for asphaltic concrete friction course, the fine specific gravity and absorption shall be done on -No.8 material. The fine specific gravity and absorption for other than asphaltic concrete friction course shall be determined on -No.4 material. “Fine aggregate” as herein referenced will be either -No.4 or -No.8 material. Sec. 1.2

PREPARATION OF TEST SAMPLE

1. Obtain a representative approximate **1200 gram** test sample of the fine aggregate. Sec. 4.1

2. **Dry** to constant mass at a temperature of **230 ± 9 °F**. (Constant mass shall be determined as follows: Dry the sample for a minimum of **1 hour** at 230 ± 9 °F. Record the weight to the **nearest 0.1 gram**. Continue drying and weighing until the weight does **not change more than 0.1 gram** at drying intervals of a minimum of **30 minutes**.) Cool to a comfortable handling temperature. Sec. 4.2

3. **Cover** with sufficient water to completely immerse it throughout the soaking period, and permit to stand for **15 to 19 hours**. Sec. 4.2

4. **Decant** excess water with care to avoid loss of fines, spread the sample on a flat **nonabsorbent surface** exposed to a gently moving current of ambient or warm air, and stir frequently to secure homogeneous drying. Sec. 4.4

5. Continue drying until the sample approaches a **free-flowing condition**. As the material begins to dry, it may be necessary to work it with your hands to **break up** any, conglomerations, lumps, or balls of material. Sec. 4.4

ARIZ 211e-15
Specific Gravity and Absorption of Fine Aggregate

6. It is intended that the **first trial** will be made with some surface water in the sample. Continue drying with constant stirring, and test at frequent intervals until the sample has reached a surface-dry condition. Sec. 4.5

7. If the first trial indicates that moisture is **not present** on the surface, thoroughly mix a **few milliliters of water** with the sample and let stand in a covered container for **30 minutes**. Then resume drying and testing at frequent intervals for the onset of the surface-dry condition. Sec. 4.5

8. With ***one hand***, hold the mold firmly on a smooth nonabsorbent surface. With the other hand, loosely **fill** the mold until overflowing and heaping **above the top** of the mold. **Lightly** tamp the sample into the mold with **25 drops** of the tamper. Each drop should start about **0.2 inch above** the top surface of the sample. **Adjust** the height to the new surface after each drop and **distribute** the drops over the surface. Sec.4.6

9. Remove loose material from around the base, and lift the mold vertically. When the fine aggregate slumps slightly, it indicates that it has reached a surface-dry condition. Sec. 4.6

PROCEDURE

1. The pycnometer shall be **calibrated** at **73.4 ± 3.1 °F** by determining the mass of pycnometer filled with water to the calibration mark to the **nearest 0.1 grams**. Sec. 5.1

2. Obtain a representative **500 ± 10** gram sample of the saturated surface-dry fine aggregate. Immediately record the weight of the sample to the **nearest 0.1 gram**. Sec. 5.2

3. **Partially fill** the pycnometer with water. Introduce the sample and fill with water to about **90 percent**. Roll and agitate to **eliminate** all air bubbles. Sec. 5.3

4. **Adding a few drops of 99% grade isopropyl Alcohol, after removal of air bubbles and prior to bringing the water level to its calibrated capacity.** Sec. 5.3 Note

5. **Add** sufficient water to bring the water to its calibrated **capacity**. Adjust its temperature to **73.4 ± 3.1 °F**. **Dry** the inside neck of pycnometer just above the calibration level. Determine and record the mass of the pycnometer, sample, and water to the **nearest 0.1 gram**. Sec. 5.4

ARIZ 211e-15
Specific Gravity and Absorption of Fine Aggregate

6. **Remove** the fine aggregate from the pycnometer and dry to **constant mass** at a temperature of **230 ± 9 °F**. **Cool** in air at room temperature for **1.0 ± 0.5 hours**. Determine and record the mass to the **nearest 0.1 gram**. Sec. 5.5

7. In lieu of removing the sample from the pycnometer, a **second portion** may be used to determine the oven dry weight. This sample must be obtained at the same time and shall weigh **within ± 0.2 grams** of the sample which is introduced into the pycnometer. Sec. 5.5 NOTE

REPORT

1. Report the specific gravity results to the nearest **0.001**. Sec. 7.1

2. Report the absorption result to the nearest **0.01%** Sec. 7.2

AASHTO T 255-00 (2012)[1]
Total Evaporable Moisture Content of Aggregate by Drying

SCOPE

1. This test method covers the determination of the percentage of evaporable moisture in a sample of aggregate by drying both surface moisture and moisture in the pores of the aggregate. Sec. 1.1.

SAMPLE

1. Secure a sample having a mass not less than the amount listed in Table 1. **Protect the sample against loss of moisture prior to determining the mass**. Sec. 6.2.

PROCEDURE

1. Determine the mass of the sample to the nearest 0.1 percent. Sec. 7.1.

2. Dry the sample thoroughly in the sample container by means of the selected source of heat, exercising care to avoid loss of any particles. Sec. 7.2.

3. The sample is thoroughly dry when further heating causes, or would cause, less than 0.1 percent additional loss in mass. Sec. 7.4.

4. Determine the mass of the dried sample to the nearest 0.1 percent after it has cooled sufficiently not to damage the balance. Sec. 7.5.

5. Calculate total evaporable moisture content as follows: Sec. 8.1.

$$p = 100(W - D)/D$$

where:

p = total evaporable moisture content of sample, percent;
W = mass of original sample, g; and
D = mass of dried sample, g.

AASHTO T 255-00 (2012)[1]
Total Evaporable Moisture Content of Aggregate by Drying

Example of determining if the sample is dry

6. If sample weighs 3658, 0.1% of the mass of the sample is;
3658 x .001 = 3.7 grams.

$$3658 \text{ Grams x} \left(\frac{0.1}{100}\right) = 3.658 = 3.7 \text{ grams}$$

7. Surface moisture is equal to the difference between the total evaporable moisture content and the absorption with all values based on the mass of a dry sample. Sec. 8.2

ARIZ 212e-96
Percentage of Fractured Coarse Aggregate Particles

SCOPE

1. A fractured face is a broken surface of an aggregate particle created by **crushing**, by other artificial means, or by nature. A face is only considered fractured if it has sharp and **well defined edges** and the projected area of the fractured face is at least **25 percent** of the maximum projected area of the aggregate particle visible considering the particle's outline at all possible orientations of the aggregate particle. Sec. 1. (c)

SAMPLE PREPARATION

1. The size of the test sample shall be a **minimum of 500 of + # 8 particles**. It is not expected that an actual count of the number of particles be made to assure compliance with this requirement. Sec. 3. & 1(a)

PROCEDURE

1. **Weigh** the test sample, and record the weight to the **nearest gram** as "Wa". The sample may be washed and dried to constant weight prior to weighing. Sec. 4. (a)

2. Spread the test sample onto a flat surface, and observe the aggregate particles under the magnifying glass with adequate light. Sec. 4. (b)

3. **Separate** the aggregate particles having at least one **fractured face** from those that are **unfractured**. If specifications require, separate aggregate particles having at least two fractured faces from those that have less than two fractured faces. Sec. 4. (c)

4. **Weigh** the fractured particles, and weigh to the **nearest gram** and record the weight as **"W_f"**. If aggregate particles with at least two fractured faces have been determined, record the weight as "W_2". Sec. 4. (d)

CALCULATIONS

1. Calculate the percentage of fractured particles, "FF", and record to the nearest percent. Sec. 5. (a)

ARIZ 233d-15
Flakiness Index of Coarse Aggregate

SAMPLE PREPARATION

1. Obtain a representative sample at least the **size** required by **Arizona Test Method 201**. Sec. 3.1

2. The sample shall be subjected to **sieve** analysis in accordance with **Arizona Test Method 201**. The coarse aggregate size fractions of **(No.8) and larger** shall be placed in individual containers. The material passing the (No.8) sieve may be discarded. Sec. 3.2

3. From each **size** fraction **(sieve)** that has a **percent retained equal to or greater than 10%**, obtain a sample of the weight specified in **the table**. Sec. 3.3

FLAKINESS INDEX TEST PROCEDURE

1. **Weigh** each test sample to the **nearest gram** and record as the "Weight of Test Sample", for the respective size fraction. Sec. 4.1

2. The particles from each size fraction shall be **individually** tested for their ability to **pass through** the appropriate slot. Weigh the material which **passes** the appropriate slot, and record to the **nearest gram** as the "Weight Passing Slot", for the respective size fraction. Sec. 4.2

CALCULATIONS FOR FLAKINESS INDEX DETERMINATION

1. Calculate the "**Percent Passing Slot**", for each respective size fraction, and record to the **nearest whole percent**. Sec. 5.2

2. Calculate the "**Flakiness Index**", and report the result to the **nearest whole percent**. Sec. 5.3

ARIZ 236c-12
Determining Ph and Minimum Resistivity of Soils and Aggregates

SAMPLE PREPARATION

1. The soil sample as received from the field shall be **dried** at a temperature not exceeding **140 °F**. Para. 3.1.1

2. A representative test sample of approximately **2000 grams** shall then be obtained by **splitting or quartering**. Para. 3.1.2

3. Screen the test sample through a **No.8** sieve. Para. 3.1.3

4. From the screened pass No.8 material, **split** out approximately **1500 grams** for the resistivity test and approximately **50 grams** for the pH test. Para. 3.1.4

5. Place the pH sample in the **100 mL** beaker and add an **equal weight** of **distilled** water. **Stir** until well mixed and then stir at regular intervals of **8 to 10 minutes for an hour**. Para. 3.1.5

6. The temperature of the **standard buffer** solutions must be within **2°F** of the **pH sample** and within the manufacturer's recommended temperature compensation range of the pH meter. Para. 3.1.6

7. In a mixing bowl, add approximately **200 mL** of **distilled water** to moisten the resistivity sample and **mix** thoroughly. Para. 3.1.7

TEST PROCEDURE FOR pH

1. **Standardize** the pH meter using two of the standard buffers: **7.0** and either **4.0** or **10.0**, whichever is **nearest** to the estimated pH of the sample. Para. 4.1

2. **Stir** the slurry mixture in the 100 mL beaker. Para. 4.3

3. Carefully **insert** the pH probe in the slurry mixture. Determine the pH reading when the meter reading **stabilizes**. Para. 4.4

4. If the pH reading is unstable, leave the electrode immersed until the pH reading has stabilized. In some cases, it may take up to 5 minutes. Para. 4.5

5. **Record** the pH value of the soil mixture, to the **nearest tenth**. Para. 4.6

ARIZ 236c-12
Determining Ph and Minimum Resistivity of Soils and Aggregates

TEST PROCEDURE FOR MINIMUM RESISTIVITY

1. Place moistened soil in **calibrated soil box**, **compact** lightly with fingers and **level off** the top with a straightedge. **Connect** the resistance meter to the side terminals of the box. Determine resistance and record to the nearest **10 ohms**. Para. 5.1

2. **Empty** the soil back into the mixing bowl and add **50 mL** of **distilled water** at room temperature and **mix** until all the water is dispersed uniformly through the soil. Para. 5.2

3. **Clean** the soil box by rinsing with **distilled water** after each test application. Para. 5.3

4. **Repeat** the above procedure, the resistance readings should **decrease** for several readings before an **increase** is noted. The **lowest** resistance reading before an increase will be the reading to use for calculating the minimum resistivity of the soil. Para. 5.5

5. The minimum resistivity value is reported to the nearest **whole number**. Para. 6.1.4

AASHTO T 19-14
Bulk Density ("Unit Weight") and Voids
In Aggregate

SCOPE

1. This test method covers the determination of bulk density ("unit weight") of aggregate in a compacted or loose condition, and calculated voids between particles in fine, coarse, or mixed aggregates based on the same determination. This test method is applicable to aggregates not exceeding 5" in nominal maximum size. Sec. 1.1.

SAMPLING

1. Obtain the sample in accordance with T 2, and reduce to test sample size in accordance with T248. Sec. 6.1.

SAMPLE

1. The size of sample shall be approximately **125 to 200 percent** of the quantity required to fill the measure and shall be handled in a manner to avoid segregation. **Dry** the sample to constant mass, preferably in an oven at **230 ± 9°F (110 ± 5°C)**. Sec. 7.1

CALIBRATION OF MEASURE

1. Measures shall be **recalibrated at least once a year** or whenever there is reason to question the accuracy of the calibration. Sec. 8.1.

2. A thin layer of grease may be placed on the rim of the measure to prevent leakage of water from the measure. Sec. 8.2

3. The glass plate shall be at least ¼" thick and 1" greater than the diameter of the measure. Weigh measure to the nearest **0.1 lb (0.05 kg)**. Sec. 5.5.1 & 8.3.

4. Fill the measure with room temperature water and cover with the plate glass to eliminate bubbles and excess water. Dry the outside of measure and plate glass. Sec. 8.4.

5. Weigh the water, plate glass, and measure to the nearest **0.1 lb (0.05 kg)**. Sec. 8.5

AASHTO T 19-14
Bulk Density ("Unit Weight") and Voids
In Aggregate

6. Measure the temperature of the water to the nearest **1°F** (0.5 °C) and determine its density from Table 3, interpolating if necessary. Sec. 8.6.

SELECTION OF PROCEDURE

1. The **shoveling** procedure shall be used only when **specifically stipulated**. Sec. 9.1.

2. The **rodding** procedure shall be used for aggregates having a nominal maximum size of **1**½**" or less**. Sec. 9.1.

3. The **jigging** procedure shall be used for aggregates having a nominal maximum size **greater than 1**½**"** and not exceeding 5 in. Sec. 9.1.

RODDING PROCEDURE

1. Fill the measure **1/3 full** and **level the surface** with the **fingers**. Sec. 10.1.

2. Rod the layer of aggregate with **25 strokes** of the tamping rod evenly distributed over the surface. Do not allow the rod to strike the bottom of the measure forcibly. Sec. 10.1., 10.2

3. Fill the measure 2/3 full and level and rod as above. Finally, fill the measure to **overflowing** and rod again as above, but do not use more force than to cause the tamping rod to penetrate the previous layer. Sec. 10.1., 10.2

4. **Level** the surface with the fingers or a straightedge in such a way that any slight **projections** of the larger pieces of the coarse aggregate approximately **balance** the larger **voids** in the surface **below** the top of the measure. Sec. 10.1.

5. In rodding the second and third layers, use vigorous effort, but not more force than to cause the tamping rod to **penetrate** to the previous layer of aggregate. Sec. 10.2.

6. **Weigh** the measure plus contents, and weigh the measure alone and record the values to the nearest 0.05 kg or **(0.1 lb)**. Sec. 10.3.

AASHTO T 19-14
Bulk Density ("Unit Weight") and Voids
In Aggregate

JIGGING PROCEDURE

1. Fill the measure in **three** approximately equal layers as described in Section 10.1. Sec. 11.1.

2. Compact each layer by placing the measure on a **firm** base, raising the **opposite** sides alternately about **2"** (50 mm) and allowing the measure to drop in such a manner as to hit with a sharp **slapping** blow. Sec. 11.1.

3. Compact each layer by dropping the measure 50 times in the manner described, **25 times on each side**. Sec. 11.1.

4. **Level** the surface with the fingers or a straightedge in such a way that any slight **projections** of the larger pieces of aggregate, approximately **balance** the larger **voids** in the surface **below** the top of the measure. Sec. 11.1.

5. **Weigh** the measure plus contents, and weigh the measure alone and record the values to the nearest **0.1 lb** (0.05kg). Sec. 11.2.

SHOVELING PROCEDURE

1. Fill the measure to **overflowing** using a shovel or scoop, discharging the aggregate from a height not to exceed **2"** (50mm) above the top of the measure. Sec. 12.1.

2. Exercise care to prevent **segregation**. Sec. 12.1.

3. **Level** the surface with the fingers or a straightedge in such a way that any slight **projections** of aggregate approximately **balance** the larger **voids** in the surface below the top of the measure. Sec. 12.1.

4. **Weigh** the measure plus contents, and weigh the measure alone and record the values to the nearest **0.1 lb**. Sec. 12.2.

REPORT

1. Report the results for bulk density to the nearest **1 lb/ft^3** (10 kg/m^3). Sec. 14.1.

2. Report the results for void content to the nearest **one percent**. Sec. 14.2.

AASHTO T 21-15
Organic Impurities in Fine Aggregates for Concrete

SCOPE

1. This test method covers two procedures for an approximate determination of the presence of injurious organic compounds in fine aggregates that are to be used in hydraulic cement mortar or concrete. One procedure uses a standard color solution and the other uses a glass color standard. Sec. 1.1.

REAGENT AND STANDARD COLOR SOLUTION

1. *Reagent Sodium Hydroxide Solution (3 percent)* — Dissolve 3 parts by mass of sodium hydroxide (NaOH) in 97 parts of water. Sec. 5.1.

2. *Standard Color Solution* — Dissolve reagent grade potassium dichromate ($K_2Cr_2O_7$) in concentrated sulfuric acid (sp gr 1.84) at the rate of 0.250 g/100 mL of acid, The solution must be freshly made for the color comparison using gentle heat if necessary to effect solution. Sec. 5.2.

TEST SAMPLE

1. Obtain a test sample of about **450 grams (1 lb)** of fine aggregate in accordance with T 248. Sample drying shall be done by **air drying only**. Sec. 7.1

PROCEDURE

1. Fill a glass bottle to the **130mL (approx. 4 1/2-fluid oz)** level with the sample of the fine aggregate to be tested. Sec. 8.1.

2. Add a three-percent Sodium Hydroxide Solution in water until the volume of the fine aggregate and liquid, indicated after shaking, is **200 mL (approx. 7 fluid oz)**. Sec. 8.2.

3. Stopper the bottle, shake vigorously, and then allow the sample to stand for **24 hours**. Sec. 8.3.

AASHTO T 21-15
Organic Impurities in Fine Aggregates for Concrete

DETERMINATION OF COLOR VALUE

1. ***(Glass Color Standard Procedure)*** — At the end of the 24-hour standing period, visually compare the color standards to the color of the supernatant liquid above the test specimen. Report the organic plate number corresponding to the Gardner Color Standard number that is the nearest the color of the supernatant liquid. Sec. 9.1

2. When using this procedure, it is not necessary to prepare the standard color solution. Sec. 9.1

3. ***(Standard Color Solution Procedure)*** — At the end of the 24-hour standing period, fill a glass bottle to the **75-mL (approximately 2 1/2-fluid oz)** level with the fresh standard color solution, prepared **not longer than 2 ½ hours** previously. Sec. 9.2

4. Hold the bottle with the test sample and the bottle with the standard color solution side by side and compare the color of light transmitted through the supernatant liquid above the test sample with the color of light transmitted through the standard color solution. Sec. 9.2

5. Record whether it is lighter, darker, or of equal color to that of the reference standard. Sec. 9.2

INTERPRETATION OF RESULTS

1. If the color of the supernatant liquid is **darker** than the color standard No. 3 (Gardner Color Standard No. 11), or the standard color solution, the fine aggregate **shall be considered to possibly contain injurious organic compounds**, and further tests should be made before approving the fine aggregate for use in concrete. Sec. 10.1.

END of DAY 1

Day 2

Check Review Questions from Day 1

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ARIZ 225b / 245a-15
Maximum Dry Density and Optimum
Moisture of Soils
By Method A / D Proctor

SCOPE

1. This test describes the procedure for determining the maximum dry density and optimum moisture content for a soil by the Method A Proctor. Some materials may be more appropriately tested by Arizona Test Method 245. Sec. 1.1

2. Method A may not be used for volcanic cinders or light porous material on which the specific gravity cannot be determined with consistency or when the moisture absorption for the coarse aggregate is greater than 4.0%. Sec. 1.2

3. **Method A** may be used except when greater than **50%** (60% for Aggregate Base) of the material is retained on the **No. 4 sieve**. **Method D** may be used except when greater than **40%** is retained on the **3/4" sieve**. Sec. 1.3

CALIBRATION OF MOLD (APPENDIX A)

1. Lightly **grease** the bottom of the mold, attach mold to baseplate, and wipe off excess grease. Sec. 1.2, 1.3, 1.4

2. **Weigh** empty mold, baseplate, and glass plate to at least the **nearest 0.1 grams**. Sec. 1.5

3. **Fill** mold with **distilled** water at room temperature 77 ± 9°F. Sec. 1.6

4. Record the temperature of the water to at least the **nearest 1°F**. Sec. 1.7

5. With a small rod remove all air **bubbles** from inside the mold and place the glass plate on the mold. Sec. 1.8

6. Remove all water from the outside of the mold, baseplate and glass plate. **Weigh** the mold, baseplate and glass plate to at least the **nearest 0.1 grams**. Sec. 1.9

ARIZ 225b / 245a-15
Maximum Dry Density and Optimum
Moisture of Soils
By Method A / D Proctor

SAMPLE

1. Enough soil material shall be provided from the field to make five compacted specimens. A minimum sample size of **20,000 grams** (approximately 45 lbs.) is normally required for **A**. **45,000 grams** (approximately 100 Ibs.) is normally required **for D**. Sec. 4.1

2. Dry the sample at a temperature not exceeding **140°F** until it becomes friable under a trowel. Sec. 4.2

3. Thoroughly break up the sample taking care to avoid reducing the natural size of individual particles. Sec. 4.3

4. Weigh the sample, and sieve it over a No. 4 sieve. If the percentage of + No. 4 material is not already known from gradation testing, save any material retained on the No. 4 sieve and weigh. Calculate the percent of + No. 4 material. Sec. 4.4

5. (method **"A"**) - If + No. 4 is greater than 50% (60% for Aggregate Base), Alternate Method D, shall be used to determine the max dry density. Sec. 4.5

6. (method **"D"**) - If +3/4" is greater than 40%, then too much rock is present to allow for a reasonable maximum dry density determination. Sec. 4.5

PROCRDURE

1. From the thoroughly blended material **passing No. 4** for (method **"A"**) or **3/4 inch** for (method **"D"**), split out **5** representative samples approximately **2500 grams** for (method **"A"**) or **3/4 inch** approximately **5000 grams** for (method **"D"**) each. Sec. 5.1

2. Thoroughly mix one sample with water, approximately **three percentage** points below optimum moisture content. Sec. 5.2

3. If desired, an additional three samples may be mixed approximately to 1 % below optimum, 1% over optimum, and 3% over optimum. The samples shall be covered with a damp cloth or sealed in air tight containers until they are compacted. Sec.5.2 NOTE

ARIZ 225b / 245a-15
Maximum Dry Density and Optimum
Moisture of Soils
By Method A / D Proctor

4. Materials which tend to be difficult to incorporate water shall require approximately 12 hours for uniform moisture absorption to be achieved. Sec. 5.3

5. Place the sample in a **4"** (method **"A"**) or **6"** (method **"D"**) mold and collar in **three equal layers**. Sec. 5.4

6. Place the mold on a dense, uniform, rigid and stable foundation during compaction. Sec. 5.4

7. **Compact** each layer with **25** (method **"A"**) or **56** (method **"D"**) uniformly distributed blows. **Drop the rammer** vertically and freely from a **height of 12"**. Sec. 5.4

8. While compacting the sample, **cover** the remaining sample in the pan with a **damp cloth**. Sec. 5.4

9. **Total depth** of compacted sample is about **5 inches**. Sec. 5.4

10. When compacting granular, free-draining materials, above optimum moisture, grease the mold according to "Appendix A" (Subsection 1.2). All excess grease shall be wiped from the mold and baseplate. Sec. 5.5

11. Carefully remove the extension collar. **Trim the sample** even with the top of the mold. **Fill voids with fines** and smooth off **even with top** of the mold. Sec. 5.6

12. **Weigh** the mold and sample. Sec. 5.6

13. Determine the wet density, "WD", of the compacted soil. Sec. 5.6

14. Remove the sample from mold and slice it vertically **through the center**. Sec. 5.9

15. Obtain a minimum of **300** grams for (method **"A"**) or **600** grams for (method **"D"**). The sample is taken from the full length and width of one of the cut faces. Sec. 5.9

16. **Weigh** the Moisture sample immediately to the **nearest 0.1 gram**, dry to **constant weight** at **230 ± 9 °F**. Record the percent moisture to the nearest **0.1%**. Sec. 5.9, 6.1

ARIZ 225b / 245a-15
Maximum Dry Density and Optimum
Moisture of Soils
By Method A / D Proctor

17. For **granular**, free-draining materials, the moisture content shall be determined using the **entire** compacted proctor specimen. Sec. 5.10

18. Select another of the samples which was split in paragraph 5.1, and if not already done, thoroughly mix with water in sufficient amount to increase the moisture content by approximately **two** percentage points. Sec. 5.11

19. Repeat the procedure in Subsections 5.3 through 5.10 for the sample at each moisture content, as necessary to establish a moisture-density curve which rises to a peak and then falls away. Sec. 5.12

MOISTURE-DENSITY RELATIONSHIP

1. The percent moisture and corresponding dry density for each of the compacted samples shall be plotted on the graph. For a good plot, the **majority** of the graph is utilized. Normally, three increments on the horizontal axis shall equal one percent of moisture, and three increments on the vertical axis shall equal one lb/ft^3 of dry density. The number of increments for one percent moisture and one lb/ft^3 shall always be the **same**. Sec. 7.1

2. On each side of the max density curve, **at least two points** should be utilized to form two straight lines. The intersection point of these two lines defines the max density and optimum moisture content for the soil. Sec. 7.2

3. The Optimum moisture content is the peak (intersection point of the two lines) of the moisture - density curve and shall be reported as “OM” to the **nearest 0.1 percent**. Sec. 7.3

4. The Maximum dry density is the peak (intersection point of the two lines) of the moisture - density curve and shall be reported as “MD” to the **nearest 0.1** $\mathbf{lb/ft^3}$. Sec. 7.4

5. The optimum moisture and maximum dry density determinations above are for the material passing the No. 4 sieve. When testing field samples for comparison to proctor optimum moisture and maximum dry density, a correction to the proctor optimum moisture and maximum dry density must be made, in accordance with ARIZ 227, for the percent rock which the field sample contains. Sec. 7.4 Note

ARIZ 225b / 245a-15
Maximum Dry Density and Optimum
Moisture of Soils
By Method A / D Proctor

ARIZ 245 (Alternate Method D) Differences

1. A minimum sample size of 45,000 grams shall be obtained. Sec. 4.1

2. Five samples, approximately 5000 grams each are split out from the passing ¾" material. Sec. 5.1

3. Each layer is compacted with 56 uniformly distributed blows. Sec. 5.4

4. Sample is placed in a 6" mold in three equal lifts. Sec. 5.4

5. A minimum 600 gram sample is taken from the full length and width of on of the cut faces for moisture. Sec. 5.9

AASHTO R58-11-(2015)
Dry Preparation of Disturbed Soil and Soil Aggregate Samples for Test

SCOPE

1. This method describe the dry preparation of soil and soil-aggregate samples, as received from the field, for mechanical analysis, physical test, moisture-density relations test, and other tests as may be desired. Sec. 1.1

APPARATUS

1. Dry samples in any suitable device capable of drying samples at a temperature not exceeding 140°F. Sec. 3.2

2. Sieves – No. 10 and No. 40 Sec. 3.3

3. Pulverizing Apparatus – Either a mortar and rubber-covered pestle or a mechanical device consisting of a power-driven, rubber-covered muller suitable for breaking up the aggregations of soil particles without reducing the size of the individual grains. Sec. 3.4

SAMPLE SIZE

1. The amounts of soil material required to perform the individual test are as follows: Sec. 4.1

2. Physical Tests – For the physical test, material passing the No. 40 sieve is required in the total amount of at least 300 grams Sec. 4.1.3

3. Liquid Limit (T89) 100 grams. Plastic Limit (T90) 20 grams. Sec. 4.1.3

AASHTO R58-11 (2015)
Dry Preparation of Disturbed Soil and Soil Aggregate Samples for Test

PREPARATION OF TEST SAMPLES

1. The soil sample as received from the field shall be dried thoroughly in air or in the drying apparatus at a temperature not exceeding 140°F. A representative test sample of the amount required to perform the desired tests shall then be obtained with the sampler, or by splitting or quartering. The aggregations of soil particles shall then be broken up in the pulverizing apparatus in such a way as to avoid reducing the natural size of individual particles Sec. 5.1

2. Alternate Methods using the No. 10 sieve – The dried sample shall be separated into two fractions using a No. 10 sieve. The fraction retained on the sieve shall be ground with the pulverizing apparatus until the aggregations of soil particles are broken into separate grains. The ground soil shall then be separated into two fractions using the No. 10 sieve. Sec. 5.2.1

3. The remaining portion of material passing the No. 10 sieve shall then be separated into two parts by means of the No. 40 sieve. The fraction retained on the No. 40 sieve shall be ground with the pulverizing apparatus in such a manner as to break up the aggregations without fracturing the individual grains. If the sample contains brittle particles, such as flakes of mica, fragments of sea shells, etc., the pulverizing operation shall be done carefully and with just enough pressure to free the finer material that adheres to the coarser particles. The ground soil shall be re-ground as before. When repeated grinding produces only a small quantity of soil passing the No. 40 sieve, the material retained on the No. 40 sieve shall be discarded. The several fractions passing the No. 40 sieve obtained from the grinding and sieving operations just described shall be thoroughly mixed together and set aside for use in performing the physical tests. Sec. 7.1

AASHTO T 89-13
Determining the Liquid Limit of Soils

SCOPE

1. The liquid limit of a soil is that water content, as determined in accordance with the following procedure, at which the soil passes from a plastic to a liquid state. Sec. 1.1.

SAMPLE

1. A sample shall be taken from the thoroughly mixed material passing the **#40 sieve** which has been obtained in accordance with **R-58** or T146. About **100** grams for Method **A**, (or **50** grams for Method **B)** Sec. 4.1. (11.1.)

ADJUSTMENT OF LIQUID LIMIT DEVICE

1. Adjust the drop of the cup so that the point on the cup that comes in contact with the base rises to a height of **10.0 ± 0.2 mm**. See Figure 2 for proper location of the gauge relative to the cup during adjustment. Sec. 5.2.

2. Place a piece of masking tape across the outside bottom of the cup parallel with the axis of the cup hanger pivot. Check adjustment by turning the crank at two revolutions per second while holding the gauge in position against the tape and cup. If a **ringing or clicking** sound is heard without the cup rising from the gauge, the adjustment is correct. If no ringing is heard or if the cup rises from the gauge, readjust the height of drop. Always **remove** tape after completion of adjustment operation. Note 4

PROCEDURE

1. Place the sample in the mixing dish and thoroughly mix with **15 to 20 mL,** Method **A** (or **8 to 10 mL,** Method **B)** of distilled or demineralized water by alternately and repeatedly stirring, kneading, and chopping with a spatula. Sec. 6.1. (12.1.)

2. Add water in increments of **1 to 3 mL**. Each increment of water shall be thoroughly mixed with the soil before another increment of water is added. Sec. 6.1.

3. Once testing has begun, **no additional dry soil** should be added to the moistened soil. Sec. 6.1.

AASHTO T 89-13
Determining the Liquid Limit of Soils

4. If **too much water** is added, the sample shall be **discarded**, or **mixed** and kneaded until natural evaporation lowers the closure point into an acceptable range. Sec. 6.1.

5. When sufficient water has been mixed with the sample place it in the cup and squeeze and spread with the spatula to a depth of **10 mm** at the point of maximum thickness. Sec. 6.2.

6. **As few strokes** of the spatula as possible shall be used, care being taken to prevent the entrapment of **air bubbles** within the mass. Sec. 6.2.

7. The excess soil shall be returned to the mixing dish and **covered** to retain the moisture in the sample. Sec. 6.2.

8. The sample shall be divided by a firm stroke of the grooving tool through the centerline of the cam follower so that a clean sharp groove is formed. Sec. 6.2.

9. To avoid tearing of the sides of the groove, up to **six strokes** from front to back or from back to front counting as one stroke, shall be permitted. The depth should be increased with each stroke and only the last stroke should scrape the bottom of the cup. Sec. 6.2.

10. The cup shall be dropped by turning the crank at the rate of about **two revolutions per second** until the two sides of the sample come in contact at the bottom of the groove along a distance of about **½”** (13 mm). The number of shocks shall be recorded. The base shall **not** be held while the crank is turned. Sec. 6.3.

11. Some soils tend to **slide** on the surface of the cup instead of flowing. If this occurs, **more water** should be added to the sample. If the soil continues to slide on the cup at a lesser number of blows than 25, the test is not applicable. Note 6

12. A **slice** of soil approximately the width of the **spatula**, extending from edge to edge of the soil cake at right angles to the groove and including that portion of the groove in which the soil flowed together, shall be removed and placed in a suitable container. The soil in the container shall be **dried** in accordance with **T 265** to determine the moisture content, and record the results. Sec. 6.4.

AASHTO T 89-13
Determining the Liquid Limit of Soils

13. The soil remaining in the cup shall be transferred to the mixing dish. The cup and grooving tool shall be **washed** and dried before the next trial. Sec. 6.5.

14. **Method A** - Repeat the foregoing operations adding sufficient water to bring the soil to a more fluid condition. Obtain the first sample in the range of 25-35, the second in the range of 20-30, and the third in the range of 15-25 shocks. The range of the three determinations shall be at least 10 shocks. Sec. 6.6.

15. **Method B** - The moisture sample taken in accordance with Section 6.4 shall be taken only for the **accepted trial**. Sec. 12.1.

16. **Method B** - The accepted number of blows shall be restricted to between **22 and 28**. After obtaining a closure in the acceptable blow range, immediately return the soil to the mixing dish and, without adding any water, **repeat**. If the second closure occurs in the acceptable range and within **two (2) blows** of the first closure, secure a water content specimen as directed in Section 6.4. Sec. 12.2.

CALCULATION

1. The water content of the soil shall be expressed as the moisture content in percentage of the mass of the oven-dried soil and shall be calculated as follows: Sec. 8.1.

$$\text{Percentage moisture} = \frac{\text{mass of water}}{\text{mass of oven - dry soil}} \times 100$$

2. Calculate the percentage of moisture to the **nearest whole percent**. Sec. 8.1.1.

LIQUID LIMIT

1. **Method A** - The moisture content corresponding to the intersection of the flow curve with the 25 shock ordinate shall be taken as the liquid limit of the soil. Report this value to the **nearest whole number**. Sec. 10.1.

2. **Method B** - The liquid limit shall be determined by one of the following methods: the nomograph, Figure 4; the correction factor method, Table 1; or by any other method of calculation that produces equally accurate liquid limit values. The standard three-point method shall be used as a referee test to settle all controversies. Sec. 14.1.

AASHTO T 90-15
Determining the Plastic Limit and Plasticity Index of Soils

SCOPE

1. The **plastic limit** of a soil is the lowest water content determined in accordance with the following procedure at which the soil remains plastic. The **plasticity index** of a soil is the range in water content, expressed as a percentage of the mass of the oven-dried soil, within which the material is in a plastic state. It is the numerical difference between the liquid limit and plastic limit of the soil. Sec. 1.1.

2. The Hand Rolling Method shall be the referee procedure. Sec. 1.3.

SAMPLE

1. If only the plastic limit is required, take a quantity of soil with a mass of about **20 g** from the thoroughly mixed portion of the material passing the **#40** sieve, and mix with distilled or demineralized water until the mass becomes plastic enough to be easily shaped into a ball. Tap water may be used for routine testing if comparative tests indicate no differences in results. (The objective is to add enough moisture so that the 3-mm thread does not crumble on the first roll.) Take a portion of this ball with a mass of about **10 g** for the test sample. Sec. 5.1.

2. If both the liquid and plastic limits are required, take a test sample with a mass of about **10 g** from the thoroughly wet and mixed portion of the soil prepared in accordance with T 89. Take the sample at any stage of the mixing process at which the mass becomes plastic enough to be easily shaped into a ball without sticking to the fingers excessively when squeezed. If it taken before completion of the liquid limit test, set it aside and allow to **season in air** until the liquid limit test has been completed. Sec. 5.2.

PROCEDURE

1. Weigh and record the mass of the moisture content container. Sec. 6.1

2. Select a 1.5 to 2.0-g portion from the soil taken in accordance with Section 5. Form the selected portion into an ellipsoidal mass. Sec. 6.2.

AASHTO T 90-15
Determining the Plastic Limit and Plasticity Index of Soils

3. Roll the soil mass into a 1/8” (3mm) diameter thread at a rate of **80 to 90 strokes per minute**, counting a stroke as one complete motion of the hand forward and back to the starting position again. Sec. 6.3.

4. Roll the mass between the palm or fingers and the ground-glass plate (or a piece of unglazed paper laying on a smooth horizontal surface) with just sufficient pressure to roll the mass into a 1/8” (3mm) thread of uniform diameter throughout its length, **taking no more than two minutes**. Sec. 6.3.1.

5. When the diameter of the thread becomes 1/8” (3mm), squeeze the thread between the thumbs and fingers into a uniform mass roughly ellipsoidal in shape, and reroll. Sec. 6.4.

6. Repeat the rolling process until the thread begins to crumble. The crumbling may occur when the thread has a diameter greater than 1/8” (3mm), this is considered to be satisfactory end point, provided it has been previously rolled to a 1/8” thread (Note 6). Do not attempt to produce failure by changing the rate of rolling or hand pressure. Continuing the rolling until the thread falls apart (Note 7). Sec. 6.4.

7. Do not attempt to produce failure at exactly 1/8” (3mm) diameter by allowing the thread to reach 1/8” (3mm), then reducing the rate of rolling or the hand pressure, or both, and continuing the rolling without further deformation until the thread falls apart. Sec. 6.4.

8. Gather the portions of the crumbled soil together and place in a weighed container. Immediately cover the container. Sec. 6.5.

9. Repeat the operations until the 8-g specimen is tested. Sec. 6.6.

10. Determine the moisture content of the soil in the containers in accordance with T 265, and record the results. Sec. 6.7.

CALCULATIONS

1. Calculate the plastic limit, expressed as the water content in percentage of the mass of the oven- dry soil, as follows: Sec. 7.1.

$$\text{Plastic Limit} = \frac{\text{mass of water}}{\text{mass of oven - dry soil}} \times 100$$

AASHTO T 90-15
Determining the Plastic Limit and Plasticity Index of Soils

2. Report the plastic limit to the nearest **whole number**. Sec. 7.1.

3. Calculate the plasticity index of a soil as the difference between its liquid limit and its plastic limit, as follows: Sec. 7.2.

$$\text{Plasticity Index} = \text{Liquid Limit} - \text{Plastic Limit}$$

4. When the liquid limit or plastic limit cannot be determined, report the plasticity index as NP (non-plastic). Sec. 7.3.1.

5. When the plastic limit is equal to, or greater than, the liquid limit, report the plasticity index as NP. Sec. 7.3.2.

AASHTO T 265-15
Laboratory Determination of
Moisture Content of Soils

TEST SAMPLE

1. Select a representative quantity of moist soil in the **amount indicated in the method of test**. If no amount is indicated, the minimum mass of the sample shall be in accordance with the following table: Sec. 5.1.

Maximum Particle Size	Minimum Mass of Sample, g
0.425-mm (No. 40) sieve	10
4.75-mm (No. 4) sieve	100
12.5-mm (1/2 in.)	300
25.0-mm (1in.)	500
50-mm (2 in.)	1000

PROCEDURE

1. Weigh a clean, dry container and lid, and place the sample in the container. Replace the lid, and weigh the container, lid and sample. Remove the lid and place the container in an oven at 110 ± 5°C (230 ± 9°F) and dry overnight (15 h minimum) or **dry until the mass loss of the sample after 1 hour of additional drying is less than 0.1 percent (constant mass)** (Notes 1 and 2). Immediately upon removal from the oven, replace the lid and allow the sample to cool to room temperature. Weigh the container including the lid and the dried sample (Notes 3 and 4). Sec. 6.1

2. In cases where there is doubt concerning the adequacy of overnight drying, drying should continue until constant mass is achieved, Samples of sand may often be dried to constant mass in a period of several hours. Since dry soil may absorb moisture from wet samples, dried samples should be removed before placing wet samples in the oven. Note 1

3. A container without a lid may be used provided the moist sample is weighed immediately after being taken and providing the dried sample is weighed immediately after being removed from the oven or after Cooling in a desiccator. Note 3

AASHTO T 265-15
Laboratory Determination of
Moisture Content of Soils

4. Moisture content samples should be discarded and should not be used in any other tests. Note 4

CALCULATION

1. Calculate the moisture content of the soil as follows: Sec. 7.1.

$$w = \left[\left(\text{mass of moisture} \right) / \left(\text{mass of oven-dry soil} \right) \right] \times 100 = \left[\left(W_1 - W_2 \right) / \left(W_2 - W_c \right) \right] \times 100 \quad (1)$$

where:

w = moisture content, percent;
W_1 = mass of container and moist soil, g;
W_2 = mass of container and oven-dried soil, g; and
W_c = mass of container, g.

2. Calculate the percent of moisture content to the nearest **0.1 percent**. Sec. 7.2.

AASHTO T 176-08 (2013)
Plastic Fines in Graded Aggregates and Soils by Use of the Sand Equivalent Test

TEMPERATURE CONTROL

1. The temperature of the working solution should be maintained at 22 ± 3°C **(72 ± 5°F)** during the performance of this test. Sec. 5.1

SAMPLE PREPARATION

1. Obtain a sample of material in accordance with T2 Sec. 6.1

2. Reduce the sample according to T248. The sample shall be of sufficient size ***to yield 1,000 to 1500 grams*** of material passing the (No. 4) sieve. Sec. 6.2

3. All aggregations of fine-grained soil material shall be pulverized to pass the (No. 4) sieve, and all fines shall be cleaned from the particles retained on the (No. 4) sieve and included with the material passing the (No. 4) sieve. Sec. 6.3

4. Split or quarter enough of the sample to ***yield 500 to 750 grams*** of material. Use extreme care to obtain a truly representative portion of the original sample. (Note 5) Sec. 6.4

5. **When it appears necessary, dampen the material before splitting or quartering, to avoid segregation or loss of fines.** Note 5

6. **Prepare the desired number** of test samples by one of the following methods: Sec. 7.1

ALTERNATE METHOD NO. 1—AIR DRY.

1. Split or quarter enough of the passing (No. 4) material to fill the 85-mL (3 oz) tin so it is slightly rounded above the brim. While filling, tap the bottom edge of the tin on the work table or other hard surface. Strike off the tin measure level full with a spatula or straightedge. Sec. 7.1.1.1

AASHTO T 176-08 (2013)
Plastic Fines in Graded Aggregates and Soils by Use of the Sand Equivalent Test

ALTERNATE METHOD NO. 2—PRE-WET.

1. The sample must be slightly more than the Saturated Surface Dry condition. If the moisture content is altered to meet these limits, the altered sample should be placed in a pan, covered, and allowed to stand for a minimum of 15 minutes. Sec. 7.1.2.1

2. Mix the sample by alternately lifting each corner of the cloth and pulling it toward the opposite corner, causing the material to be rolled. When the material appears homogeneous, finish the mixing with the sample in a pile near the center of the cloth. Sec. 7.1.2.2

3. Fill the tin by pushing it through the base of the pile while exerting pressure with the hand against the pile on the side opposite the tin. As the tin is moved through the pile, hold enough pressure with the hand to cause the material to fill the tin to overflowing. Press firmly with the palm of the hand, compacting the material in the tin. Strike off the tin measure level full with a spatula or straightedge. Sec. 7.1.2.3

REFERENCE METHOD (MECHANICAL SHAKER)

1. **Obtain the 85-mL (3-oz) tin of material by one of the alternate methods, Section 7.1.1.1 or 7.1.2.3, above;**
2. **Dry the test sample(s) to constant mass at 110 ± 5°C (230 ± 9°F)**, and cool to room temperature before testing. **A mechanical shaker shall be used**. Sec. 7.1.3

PROCEDURE

1. Siphon 101.6 ± 2.5 mm (4.0 ± 0.1 in.) of working calcium chloride solution into the plastic cylinder. Sec. 8.2

2. Pour the sample into the plastic cylinder using the funnel to avoid spillage. Tap the bottom of the cylinder sharply on the heel of the hand several times to release air bubbles and to promote thorough wetting of the sample. Sec. 8.2

3. Allow the wetted sample to stand undisturbed for 10 ± 1 minute. Sec. 8.3

AASHTO T 176-08 (2013)

Plastic Fines in Graded Aggregates and Soils by Use of the Sand Equivalent Test

4. Stopper the cylinder, then loosen the material from the bottom by partially inverting the cylinder and shaking it simultaneously. Sec. 8.3

5. Mechanical Shaker Method (Reference Method)—Place the stoppered cylinder in the mechanical sand equivalent shaker, and shake the cylinder for 45 ± 1 second. Sec. 8.4

IRRIGATION PROCEDURE

1. Insert the irrigator tube in the cylinder and rinse material from the cylinder walls as the irrigator is lowered. Force the irrigator through the material to the bottom of the cylinder by applying a gentle stabbing and twisting action while the working solution flows from the irrigator tip. Continue to apply the stabbing and twisting action until the cylinder is filled to the 15" mark. Then raise the irrigator slowly without shutting off the flow so that the liquid level is maintained at about 15" while the irrigator is being withdrawn. Regulate the flow just before the irrigator is entirely withdrawn and adjust the final level to 15". Final level as judged by the bottom of the meniscus shall be between the top two graduations on the tube but shall not be above the 15" level. Sec. 8.6

2. Allow the cylinder and contents to stand undisturbed for 20 minutes ± 15 seconds. Start the timing immediately after withdrawing the irrigator tube. Sec. 8.7

3. At the end of the 20-minute sedimentation period, read and record the level of the top of the clay suspension. This is referred to as the "clay reading". If no clear line of demarcation has formed at the end of the specified 20-minute sedimentation period, allow the sample to stand undisturbed until a clay reading can be obtained, then immediately read and record the level of the top of the clay suspension and the total sedimentation time. If the total sedimentation time exceeds 30 minutes, rerun the test using three individual samples of the same material. Read and record the clay column height of that sample requiring the shortest sedimentation period only. Sec. 8.8

AASHTO T 176-08 (2013)

Plastic Fines in Graded Aggregates and Soils by Use of the Sand Equivalent Test

4. Place the weighted foot assembly over the cylinder and gently lower the assembly toward the sand. Do not allow the indicator to hit the mouth of the cylinder. As the weighted foot comes to rest on the sand, tip the assembly toward the graduations on the cylinder until the indicator touches the inside of the cylinder. Subtract (10 in.) from the level indicated by the extreme top edge of the indicator and record this value as the "sand reading". Sec. 8.9.1

5. If clay or sand readings fall between (0.1 in.) graduations, record the level of the higher graduation as the reading. For example, a clay reading of 7.95 would be recorded as 8.0, and a sand reading of 3.22 would be recorded as 3.3. Sec. 8.10

CALCULATION

1. Calculate the Sand Equivalent (SE) to the nearest 0.1 using the following formula. Sec 9.1

$$SE = \frac{\text{Sand Reading}}{\text{Clay Reading}} \times 100 \qquad SE = \frac{3.3}{8} \times 100 = 41.3$$

2. If the calculated sand equivalent (SE) is not a whole number, report it as the next higher whole, number, as in the following example: (41.3 = 42).

3. When averaging three results you will sum the three rounded numbers and divide by 3 (See below). Since the average value is not a whole number it is raised to the next higher whole number. Sec. 9.2

$$\frac{42 + 44 + 41}{3} = 42.3 = 43$$

ARIZ 105f-14
Sampling Soils and Aggregates

SAMPLING STOCKPILES

1. To ensure unbiased samples, due to segregation, power equipment may be used to build small sampling piles composed of materials drawn from various levels and locations in the main stockpile. Once a small stockpile has been established then a sample shall be taken from that pile by taking several increments and combining. Sec. 2.1

2. Place a wood or metal **shield** upslope from the sampling point. Sec. 2.2

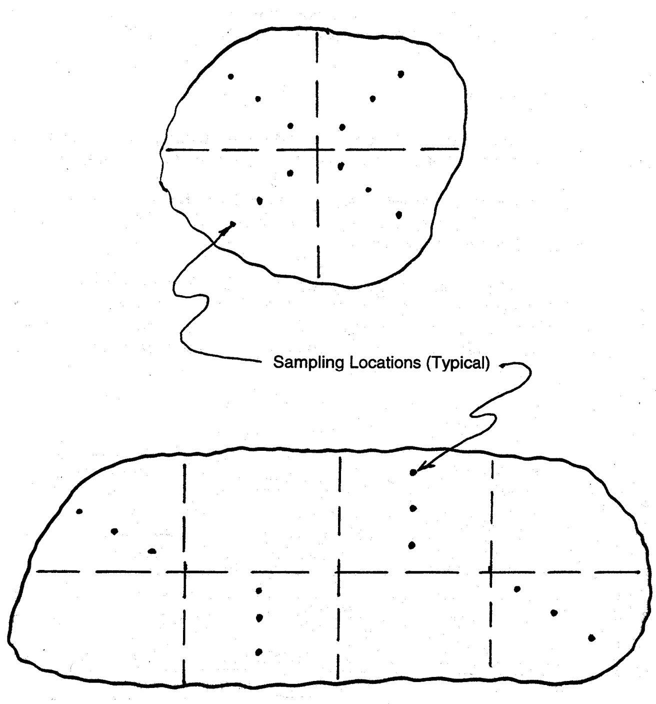
3. Remove **3-6 inches** of material from in front of the shield. Sec. 2.2

4. With a square point shovel obtain **one shovelful** of material near the **top, middle and bottom** of the stockpile. Sec. 2.2

5. Obtain **one** shovelful of material **per location**. Sec. 2.2

6. Combine all samples. Sec. 2.2

7. Samples are taken from **each quarter** of round stockpiles and from **every other section** of oblong stockpiles. Figure 1.



ARIZ 105f-14
Sampling Soils and Aggregates

SAMPLING BINS

1. Sufficient material is allowed to pass to ensure uniformity of material. Sec. 3.1

2. Pass sampling device through the **entire cross-section** of material being discharged. Sec. 3.1

3. Repeat as needed to obtain desired amount of material. Sec. 3.1

SAMPLING CONVEYOR BELTS

1. **If belt is running**, samples of the aggregate shall be taken utilizing a sampling device to divert or intercept the entire flow of material in such a manner that all portions of the flow are diverted or intercepted for an equal amount of time. Sec. 4.1.1

2. **If belt is stopped**, make sure the belt is locked down and place a template which is shaped to the same contour and width of the belt so that it is in full contact with the belt. Sec. 4.1.2

3. Remove all material from within the template; **using a brush to obtain all the fine aggregate**. Sec. 4.1.*2*

SAMPLING FROM A WINDROW

1. **Remove sufficient amount** of material from the top of the windrow to obtain a representative sample. Sample is obtained from the **center** of the freshly exposed portion of the windrow. Sec. 5.1

2. **One shovelful** of material is taken from each location. Sec. 5.1

3. All samples are combined and placed in a container. Sec. 5.1

SAMPLING FROM A ROADWAY

1. **Three** samples taken with a shovel at **equal distance apart**, across the roadway. Sec. 6.1

2. Normally the sample taken to the **entire depth** of the lift being tested. Sec. 6.1

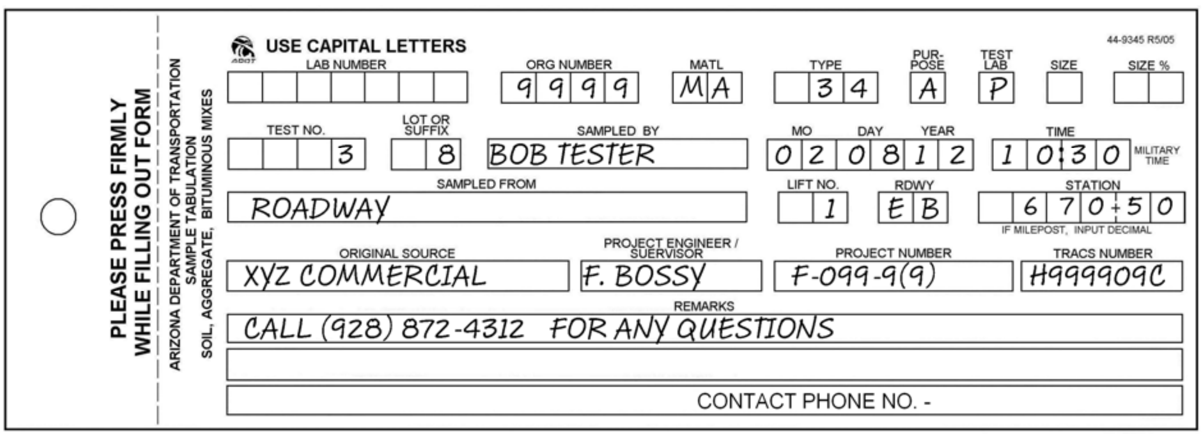
ARIZ 105f-14
Sampling Soils and Aggregates

3. Obtain **all material** from the hole and combine all material. Sec. 6.1

SAMPLE IDENTIFICATION

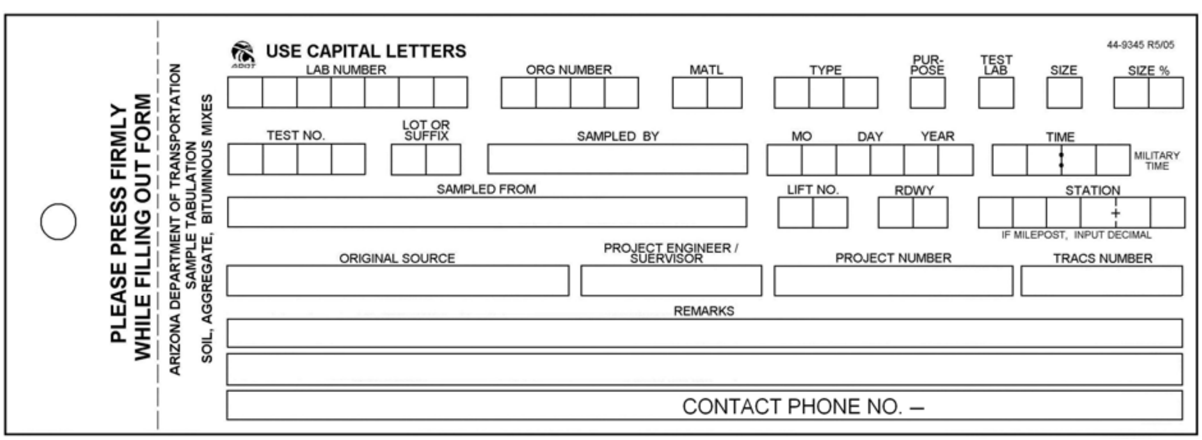
1. Each sample shall be identified by an accompanying sample ticket. The remarks area shall be used to provide additional information, including the phone number of the individual who can be contacted regarding the sample. Para. 8.1

2.



PLEASE PRESS FIRMLY WHILE FILLING OUT FORM
ARIZONA DEPARTMENT OF TRANSPORTATION SAMPLE TABULATION
SOIL, AGGREGATE, BITUMINOUS MIXES
USE CAPITAL LETTERS
44-9345 R5/05
LAB NUMBER | ORG NUMBER 9999 | MATL MA | TYPE 34 | PUR-POSE A | TEST LAB P | SIZE | SIZE %
TEST NO. 3 | LOT OR SUFFIX 8 | SAMPLED BY BOB TESTER | MO 02 | DAY 08 | YEAR 12 | TIME 10:30 MILITARY TIME
SAMPLED FROM ROADWAY | LIFT NO. 1 | RDWY EB | STATION 670+50 IF MILEPOST, INPUT DECIMAL
ORIGINAL SOURCE XYZ COMMERCIAL | PROJECT ENGINEER / SUERVISOR F. BOSSY | PROJECT NUMBER F-099-9(9) | TRACS NUMBER H999909C
REMARKS CALL (928) 872-4312 FOR ANY QUESTIONS
CONTACT PHONE NO. -

3.



PLEASE PRESS FIRMLY WHILE FILLING OUT FORM
ARIZONA DEPARTMENT OF TRANSPORTATION SAMPLE TABULATION
SOIL, AGGREGATE, BITUMINOUS MIXES
USE CAPITAL LETTERS
44-9345 R5/05
LAB NUMBER | ORG NUMBER | MATL | TYPE | PUR-POSE | TEST LAB | SIZE | SIZE %
TEST NO. | LOT OR SUFFIX | SAMPLED BY | MO | DAY | YEAR | TIME MILITARY TIME
SAMPLED FROM | LIFT NO. | RDWY | STATION IF MILEPOST, INPUT DECIMAL
ORIGINAL SOURCE | PROJECT ENGINEER / SUERVISOR | PROJECT NUMBER | TRACS NUMBER
REMARKS
CONTACT PHONE NO. –

AASHTO T 248-14
Reducing Samples of Aggregate to Testing Size

SELECTION OF METHOD

1. ***Fine Aggregate*** — Samples of fine aggregate that are **drier** than the saturated-surface-dry condition shall be reduced by a mechanical splitter according to **Method A**. Samples having **free moisture** may be reduced by quartering according to **Method B**, or by a **miniature stockpile** as described in **Method C**. Sec. 5.1.

2. If **Method A** is desired and the **Fine Aggregate** sample has free moisture on the particle surfaces, the entire sample may be dried to at least the surface-dry condition, and then the sample reduction performed. Alternatively, if the **moist sample** is very large, **a preliminary split** may be made using a **mechanical splitter** having wide chute openings 38 mm **(1 1/2 in.)** or more, to reduce the sample to **not less than 5000 g**. The portion so obtained is then **dried**, and reduction to test sample size is completed using **Method A**. Sec. 5.1.2.

3. ***Coarse Aggregates*** — Reduce the sample using a **mechanical splitter** in accordance with **Method A** (preferred method) or by **quartering** in accordance with **Method B**. The miniature stockpile Method C is not permitted for coarse aggregates or mixtures of coarse and fine aggregates. Sec. 5.2.

4. ***Coarse Aggregates and Mixtures of Coarse and Fine Aggregates***—Samples that are in a dry condition may be reduced using a **mechanical splitter** in accordance with **Method A** or by **quartering** in accordance with **Method B**. Samples having free moisture on the particle surfaces may be reduced in size by quartering **Method B**. When Method A is used dry the sample until it appears dry or until clumps can be easily broken by hand (Note 2) Sec. 5.3.

Method "A" Mechanical	**Method "B" Quartering**	**Method "C" Mini Stockpile**

MATERIAL TYPE	***METHOD***
Fine Agg > SSD (Wetter than SSD)	(A*), B, C
Coarse Agg & Fine Agg Mixture	A, B
Coarse Aggregate	A, B
Fine Agg < SSD (Dryer than SSD)	A

*****(If using (Method A) then the splitter openings must be at least 1-1/2" wide, and reduced down to not less than 5,000 g.)

AASHTO T 248-14
Reducing Samples of Aggregate to Testing Size

METHOD A—MECHANICAL SPLITTER

1. **Sample splitters** shall have an even number of equal width chutes, but not less than **eight** (8) for coarse aggregate or twelve (**12)** for fine aggregate. For **coarse aggregate** and **mixed aggregate** the minimum width of the chutes shall be approximately **50 percent larger** than the largest particles in the sample. Sec. 7.1.

2. For **dry fine aggregate** in which the entire sample will pass the **3/8"** sieve, the minimum width of the chutes shall be at least **50 percent larger** than the largest particles, with a max width of **3/4 in.**. The splitter shall be equipped with two (2) receptacles to hold the two halves of the sample following splitting. It shall also be equipped with a hopper or straightedged pan which has a width equal to or slightly less than the overall width of the assembly of chutes. The sample shall flow smoothly without restrictions or loss of material. Sec. 7.1.

PROCEDURE

1. Place the sample in the hopper or pan and **uniformly distribute** it from edge to edge. The rate shall be such as to allow free flowing through the chutes into the receptacles below. Sec. 8.1

2. **Reintroduce** the sample in one of the receptacles into the splitter as many times as necessary to reduce the sample to the size specified. Sec. 8.2

METHOD B—QUARTERING

1. Place the sample on a hard, clean, level surface where there will be neither loss of material nor accidental addition of foreign material. Mix the material by turning the entire sample over at least three times until the material is thoroughly mixed. With the last turning, form the entire sample into a conical pile by depositing individual lifts on top of the preceding lift. Carefully flatten the conical pile to a uniform thickness and diameter by pressing down the apex with a shovel or trowel so that each quarter sector of the resulting pile will contain the material originally in it. The diameter should be approximately 4 to 8 times larger than the thickness. Divide the flattened pile into four equal quarters with a shovel or trowel and remove two diagonally opposite quarters, including all fine material, and brush the cleared spaces clean. The two unused quarters

AASHTO T 248-14
Reducing Samples of Aggregate to Testing Size

may be set aside for later use or testing, if desired. Successively mix and quarter the remaining material until the sample is reduced to the desired size. Sec. 10.1.1.

1. As an alternative to the previous section or when the floor surface is uneven, the samples may be placed on a canvas blanket and mixed with a shovel or trowel, or as an alternative to mixing with the shovel or trowel, lift each corner of the blanket or tarp and pull it over the sample toward the diagonally opposite corner, causing the material to be rolled. After the material has been rolled a sufficient number of times **(minimum of 4 times)** so that it is thoroughly mixed, pull each corner of the blanket or tarp toward the center of the pile so the material will be left in a conical pile. Sec. 10.1.2.

2. Flatten the pile as described in the previous section. Divide the pile by inserting a stick or pipe beneath the blanket or tarp and under the center of the pile, lift both ends of the stick, dividing the sample into two equal parts. Remove the stick, leaving a fold of the blanket between the divided portions. Insert the stick under the center of the pile, at right angles to the first division and again, lift both ends of the stick, dividing the sample into four equal parts. **Remove two diagonally opposite quarters**. Being careful to **clean the fines from the blanket or tarp**. Successively mix and quarter the remaining material until the sample is reduced to the desired size. Sec. 10.1.2.

METHOD C—MINIATURE STOCKPILE SAMPLING (DAMP FINE AGGREGATE ONLY)

1. Place the original sample of damp fine aggregate on a hard, clean level surface where there will be neither loss of material nor the accidental addition of foreign material. Mix the material by turning the entire sample over at least three times until the material is thoroughly mixed. With the last turning, form the entire sample into a conical pile by depositing individual lifts on top of the preceding lift. If desired the conical pile may be flattened to a uniform thickness and diameter by pressing the apex with a shovel or trowel so that each quarter sector of the resulting pile will contain the material originally in it. Obtain a sample for each test by selecting **at least 5 increments** of material at random locations from the miniature stockpile, using any of the sampling devices such as; straightedged scoop, shovel, small sampling thief, small scoop, or spoon. Sec. 12.1

END of CLASS

Intermodal Transportation

SOILS & AGG TECHNICIAN REVIEW TRAINING

Study Guide Calculations

and Key

January 2016

PERCENT PASSING CALCULATION (ARIZ 201)

To calculate percent passing you will need a scientific calculator with at least one memory.

Always add up all the weights, **never change the amount in the total box**. If the calculated total is 1.0% or less from the total in the total box, adjust the number of the sieve weight with the largest amount retained except for the passing #4.

COARSE SIEVE

a. To get the Coarse sieve factor, divide 100 by the total weight of sample (the number in the total box).
b. Place the factor in the memory of the calculator (MR+).
c. Enter 100 in the calculator, subtract the first weight retained, times (x) the factor (memory recall) (MR),then the = key this will give you the % passing that sieve.
d: Keeping that number in the calculator subtract the next weight retained, multiply it by the factor (MR) until all % passing is calculated and recorded.
e. Continue this down to the #4 weight retained.
f. Then do a check on the pass #4 by, multiplying the weight passing the #4 times the factor (MR).

FINE SIEVE

Always add up all the weights, **never change the amount in the total box**. If the calculated total is 1.0% or less from the total in the total box, adjust the number of the sieve weight with the largest amount retained except for the passing #200.

a. Subtract the "Total Dry Weight" from the "Dry Wt. of -#4 Split" weight to get the elutriation weight and record it in the box provided.
b. To get the fine sieve factor, take the % passing the #4 (whole number) and divide it by the adjusted split weight. ***(If the minus #4 was not split, do not calculate a fine factor, use the coarse factor continuing down through the fine sieve analysis).***
c. Place the factor in the memory of the calculator.
d. Enter the % pass the #4 (whole number) in the calculator, subtract the weight retained on the #8 sieve, multiply, (x) it by the factor (MR) = to get the % passing the #8.
e. Keeping that number in the calculator subtract the next weight retained (#10), multiply (x) it by the factor (MR) until all % passing is calculated and recorded.
f. Continue this procedure down to the #200.
g. Do a check on the pass #200 by multiplying the (weight passing the 200 sieve plus + the elutriation weight) by the factor (MR).

When all the percent pass results are recorded, you may now record the percent retained for each sieve. Start with the largest % pass and subtract the next smaller % pass from it. Continue this down to the #200 sieve.

ARIZONA DEPARTMENT OF TRANSPORTATION

SOIL AND AGGREGATE TABULATION

USE CAPITAL LETTERS

LAB NUMBER	ORG NUMBER	MATL	TYPE	PUR-POSE	TEST LAB	SIZE	SIZE %

TEST NO.	LOT OR SUFFIX	SAMPLED BY	MO DAY YEAR	TIME (MILITARY TIME)

SAMPLED FROM	LIFT NO.	RDWY	STATION (IF MILEPOST, INPUT DECIMAL)

ORIGINAL SOURCE	PROJECT ENGINEER / SUPERVISOR	PROJECT NUMBER	TRACS NUMBER

REMARKS

Review Class Calculations Key

CONTACT PHONE NO. - (   )   -

ARIZ 201
☐ Dried to Constant Wt.
☐ Not Dried to Constant Wt.

ARIZ 248
☐ Alt. 1 ☐ Alt. 2 ☐ Alt. 3
☐ Alt. 4 ☐ Alt. 5

% OVERSIZE
+ 3 " ____ + 6 " ____

COARSE FACTOR ____ = 100 / COARSE SIEVE TOTAL

WET SAMPLE PREWEIGHT = ______
WET WT. OF - # 4 = ______
- # 4 SPLIT WET WT. = ______

	WEIGHTS RETAINED	% RET.	% PASS	SPECS.	CUMULATIVE % RET. FINENESS MODULUS
3"					
2 1/2"					
2"					
1 1/2"	0				
1"	319				
3/4"	1194				
1/2"	1736				
3/8"	904				
1/4"	1002				
# 4	616				
- # 4	7045				
Total	12820				

IF TOTAL SAMPLE IS WASHED:
UNWASHED WT. = ______
WASHED WT. = ______
ELUTRIATION = ______

DRY WT. OF - # 4 SPLIT: 558

FINE FACTOR ____ = % PASS # 4 / DRY WT. OF - # 4 SPLIT

	WEIGHTS RETAINED	% RET.	% PASS	SPECS.	
#8	99				
#10	22				
#16	74				
#30	113				
#40	59				
#50	52				
#100	64				
#200	34				
-#200	6				
Total	521	Dry Weight			
Elutriation		= -#4 Split - Total Dry Weight			

FINENESS MODULUS = TOTAL CUMULATIVE % RET. / 100

T = AASHTO Tests

Test	Method	Result	Unit	SPECS.
Liquid Limit (LL)	T - 89			
Plastic Limit (PL)	T - 90			
Plasticity Index (PI) = LL - PL	T - 90			
Abrasion Method (A,B,C,D)	T - 96			
@ 100 Revolutions			%	%
@ 500 Revolutions			%	%
Absorption, H_2O	ARIZ 210 ARIZ 211		%	
Specific Gravity, SSD	ARIZ 210 ARIZ 211			
Specific Gravity, OD	ARIZ 210 ARIZ 211			
Specific Gravity, Apparent	ARIZ 210 ARIZ 211			
Proctor Method				A - ARIZ 225 C - ARIZ 226 D - ARIZ 226 AD - ARIZ 245 A1 - ARIZ 232 AD1 - ARIZ 246
Optimum Moisture			%	
Max. Dry Density			PCF	
Sand Equivalent	T - 176 ARIZ 242 (MAFC)			
At Least One Fractured Face	ARIZ 212		%	%
At Least Two Fractured Faces	ARIZ 212		%	%
Uncompacted Void Content	ARIZ 247		%	%
Moisture Content	T - 255 T - 265		%	
Flakiness Index	ARIZ 233		%	%
Carbonates	ARIZ 238		%	%
pH	ARIZ 236 OR 237			
Resistivity (ohm-cm)	ARIZ 236			
Soluable Salts (PPM)	ARIZ 237			
Unit Weight	T - 19		PCF	
Voids	T - 19		%	
Organic Imputities	T - 21			
Chloride Content (PPM)	ARIZ 736			
Sulfate Content (PPM)	ARIZ 733			
Exchangeable Sodium (%)	ARIZ 729			
Exchangeable Sodium (PPM)	ARIZ 729			

WHITE ☐
YELLOW ☐
BLUE ☐

RECEIVED DATE ______ TEST OPERATOR & DATE ______ SUPERVISOR & DATE ______

Specific Gravity and Absorption of Fine Aggregate (ARIZ 211)

Bulk Sp. Gr. (O.D. basis) $= \dfrac{A}{B + S - C}$ = ( ) / ( ) + ( ) - ( ) = ______

Where: A = mass of oven-dry sample in air, g. **499.9**
B = mass of pycnometer filled with water, g. **683.7**
C = mass of pycnometer with sample and water to calibration mark, g. **990.1**
S = mass of saturated-surface-dry sample, g. **503.3**

Bulk Sp. Gr. (SSD basis) = $= \dfrac{S}{B + S - C}$ = ( ) / ( ) + ( ) - ( ) = ______

Apparent Sp. Gr. $= \dfrac{A}{B + A - C}$ = ( ) / ( ) + ( ) - ( ) = ______

Absorption, percent $= \dfrac{S - A}{A}$ **x 100** = ( ) - ( ) / ( ) x 100 = ______ %

Specific Gravity and Absorption of Coarse Aggregate (ARIZ 210)

Bulk Sp. Gr. (O.D. basis) $= \dfrac{A}{B - C}$ = ( ) / ( ) - ( ) = ______

Where: A = mass of oven-dry sample in air, g. **4197**
B = mass of saturated-surface-dry sample in air, g. **4291**
C = mass of saturated sample in water, g. **2610**

Bulk Sp. Gr. (SSD basis) = $= \dfrac{B}{B - C}$ = ( ) / ( ) - ( ) = ______

Apparent Sp. Gr. $= \dfrac{A}{A - C}$ = ( ) / ( ) - ( ) = ______

Absorption, percent $= \dfrac{B - A}{A}$ **x 100** = ( ) - ( ) / ( ) x 100 = ______ %

Flakiness Index (ARIZ 233)								
Sieve Size	**1-1/2"**	**1"**	**3/4"**	**1/2"**	**3/8"**	**1/4"**	**# 4**	**# 8**
% Pass from Sieve Analysis								
% Ret. From Sieve Analysis (**F**)								
Weight of Test Sample			1610	1061				72
Weigh Passing Slot			258	173				12
***** Percent Passing Slot (**P**)								
NOTE: Only the size fractions which have 10 or more percent retained are tesed for passing the appropriate slot, and used to determine the Flakiness Index by the eequation below.	* Percent Passing Slot (P) = $\frac{\textbf{Weight Passing Slot}}{\textbf{Weight of Test Sample}}$ **x 100**							

FLAKINESS INDEX = $\frac{\{F\ (11/2")\ X\ P\ (11/2")\} + \ldots\ldots + \ldots\ldots + \{F\ (No.\ 8\ X\ P\ (No.\ 8)\}}{\{F\ (1\text{-}1/2")\ + \ldots\ldots + \ldots\ldots + \{F\ (No.\ 8)\}}$

Fractured Particles (ARIZ 212)

At least one Fractured Face:

Wt. of test sample (Wa) = **376**

Wt. of fract. Particles(Wf) = **312**

Fract. Particles (FF) = $\frac{Wf}{Wa}$ **x 100** = ______ %

At least two Fractured Face:

Wt. of test sample (Wa) = NA

Wt. of fract. Particles(W2) = NA

Fract. Particles (FF**2**) = $\frac{W\ 2}{Wa}$ x 100 = ______ %

FLAKINESS INDEX = $\frac{(\quad x \quad) + (\quad x \quad) + (\quad x \quad) =}{(\quad) + (\quad) + (\quad) =}$ = ______ %

Moisture Content (T255, T265) = $\frac{\text{Wet Weight - Dry Weight}}{\text{Dry Weight}} \times 100 = \frac{(\ \mathbf{380.1}\ ) - (\ \mathbf{331.0}\ )}{(\ \mathbf{331.0}\ )}$ **x 100 =** ______ %

Sand Equivalent
AASHTO T176)
(ARIZ 242 FOR M.A.F.C)

Sand Reading 4.1
Clay Reading 5.5
Sand Equiv. ______

Sand Reading 4.2
Clay Reading 5.5
Sand Equiv. ______

Sand Reading 4.3
Clay Reading 5.7
Sand Equiv. ______

$$\frac{\textbf{Sand Reading}}{\textbf{Clay Reading}} \times 100$$

Average Sand Equiv. = ______

Abrasion
AASHTO T96)

$$\% \text{ Abrasion} = \frac{A - B}{A} \times 100$$

Where: A = Original Mass (5000 ± 10 grams)

B = Plus # 12 Material after Abrasion

100 Rev.: ______ - ______ x 100 = ______ %

500 Rev.: ______ - ______ x 100 = ______ %

Type of Abrasion ______

Soils & Agg Review Class Calculations

Plasticity Index
(AASHTO T89 & 90)

Liquid Limit (LL) :

Bottle # A Tare Wt. of Bottle: 13.28 # Blows 25

% Moisture =

$$\frac{\textbf{(Wet Wt. With Bottle) - (Dry Wt. With Bottle)}}{\textbf{(Dry Wt. With Bottle - Tare Wt. of Bottle)}} \textbf{ x 100 =}$$

$$= \frac{(\textbf{29.96} - \textbf{25.19})}{(\quad - \quad)} \times 100 = \_\_\_\_\_\_ \%$$

Liquid Limit = ______ (For 25 Blows)

Plastic Limit (PL) :

Bottle # **B** **Tare Wt. of Bottle: 16.15**

$$\frac{\textbf{(Wet Wt. With Bottle) - (Dry Wt. With Bottle)}}{\textbf{(Dry Wt. With Bottle - Tare Wt. of Bottle)}} \textbf{ x 100 =}$$

$$= \frac{(\textbf{27.36} - \textbf{25.05})}{(\quad - \quad)} \times 100 = \_\_\_\_\_\_ \%$$

Plastic Limit = ______

Plasticity Index (PI) :

PI = (LL - PL) = (______) - (______) = ______

AASHTO T19
UNIT WEIGHT AND VOIDS IN AGGREGATE

Date of Calibration: *Soils Review Class Calculations* Test Operator: ____________

Measure Identification: 1 (1/4 lb/ft^3)

Mass of Glass Plate: **0.2** **LB.**

C = Mass of Measure and Glass Plate: **8.3** **LB.**

B = Mass of measure filled with Water and Glass Plate: **23.8** **LB.**

Mass of Water used to fill Measure: ____________ **LB.**

Temperature of Water: **67** ° F **D =** Density of Water from Table 3 = ____________ lb/ft^3

V = Volume of Measure = $\left[\frac{(B - C)}{D}\right]$ = **V=** $\frac{(\quad) - (\quad)}{(\quad)}$ = ________ ft^3

Procedure (check one): [x] Rodding [ ] Jigging [ ] Shoveling

Mass of Measure, **T =** ____________ LB.

Mass of Measure and Aggregate, **G =** 27.2 LB.

Table 3		Density of Water	
Temperature			
°C	°F	Kg/m^3	Lb/ft^3
15.6	60	999.01	62.366
18.3	65	998.54	62.336
21.1	70	997.97	62.301
(23.0)	(73.4)	(997.54)	(62.274)
23.9	75	997.32	62.261
26.7	80	996.59	62.216
29.4	85	995.83	62.166

Unit Weight (Oven Dry) of Aggregate, **M = (G - T) / V**

M = $\frac{(\quad - \quad)}{(\quad)}$ = ____________ lb/ft^3

Unit Weight (SSD) of Aggregate, M_{SSD} = $\mathbf{M \times \left(1 + \frac{A}{100}\right)}$

Where A = Percent Absorption from ARIZ 210 test method.

$\mathbf{M_{SSD}} =$ (____________) x $\left[1 + \frac{\quad}{100}\right]$ = ________ lb/ft^3

Void Content = $\frac{100 \times [(S \times W) - M]}{(S) \times (W)}$

Where S = Bulk Specific Gravity (oven dry) from ARIZ 210 test method

Where W = **62.3** lb/ft^3 (Density of Water)

Void Content = $\frac{100 \times [(\quad) \times (\quad) - (\quad)]}{(\quad) \times (\quad)}$ = ________ %

ARIZONA DEPARTMENT OF TRANSPORTATION

CALIBRATION OF PROCTOR MOLD
ARIZ 225 Appendix A

✓ Four Inch Mold ______ Six Inch Mold Mold I. D. #: 4A

Calibration Date: 12/01/15 Calibration Expiration Date: 12/01/15

Temperature of water used for Calibration: 73 ° F

Unit Weight of Water: ____________ lb. /cu. ft.

Test Operator: ____________ Supervisor and Date: ____________

Weight of Baseplate, Empty Mold, and Glass Plate (grams)	Weight of Baseplate, Mold Filled with Water, and Glass Plate (grams)	Weight of Water to Fill Mold (grams)
4526.7	5465.5	

$$V = \left[\begin{matrix}\textbf{Volume of}\\ \textbf{Mold}\\ \textbf{(cu. ft.)}\end{matrix}\right] = \frac{\textbf{Weight of Water to Fill Mold (grams)}}{\left[\begin{matrix}\textbf{Unit Weight}\\ \textbf{of Water}\\ \textbf{(lb. / cu. ft.}\end{matrix}\right] \times \left[\textbf{453.6 (grams / lb.)}\right]}$$

$$V = \frac{(\qquad\qquad)}{(\qquad) \times (\ 453.6\ )} = \underline{\qquad\qquad} \text{ cu. ft.}$$

REMARKS: ____________

Unit Weight of Water Table

Temp °F	lbs/cu. Ft.	Temp °F	lbs/cu. Ft.
68	62.315	77	62.243
69	62.308	78	62.234
70	62.301	79	62.225
71	62.293	80	62.216
72	62.285	81	62.206
73	62.277	82	62.196
74	62.269	83	62.186
75	62.261	84	62.176
76	62.252	85	62.166
		86	62.155

Arizona Department of Transportation

METHOD A or **ALTERNATE METHOD D** PROCTOR DENSITY

(Arizona Test Method 225 or 245)

Project No: S & A Study Guide Calculations Lab No : ______ Rec'd Date: ______

Source and Type of Material : ______

Proctor Method Used : **Method A** ✓ or **Alternate Method D** ______

Test Operator and Date : ______ Supervisor and Date: ______

Weight of Mold = **M2** = **2036** grams | Volume of Mold = **VM** = ______ cu ft | **a** = VM x 453.6 = ______

b	M1	c	WD	ED	WW	DW	d	e	DD
					Moisture Determination				
Approx % of water Added	Wt. of Sample and Mold	Wet Wt. of Sample M1 - M2	Wet Density lb/ cu ft c / a	Est. Dry Density WD x 100 / b + 100	Wet Wt. of Moisture Sample	Dry Wt. of Moisture Sample	Wt. of Water WW - DW	Percent Moisture d x 100 / DW	Dry Density lb/cu ft WD x 100 / e + 100
6	3890				302.4	285.2			
8	4002				311.4	287.6			
10	4079				315.4	285.0			
12	4066				312.5	278.4			

METHOD A

WT = ______ WR4 ______

PR4 = WR4 / WT x 100 = ______ %

ALTERNATE METHOD D

WT = N/A WR 3/4 N/A

PR 3/4 = WR 3/4 / WT x 100 = ______ %

Coarse Aggregate Bulk Oven Dry Specific Gravity : ______

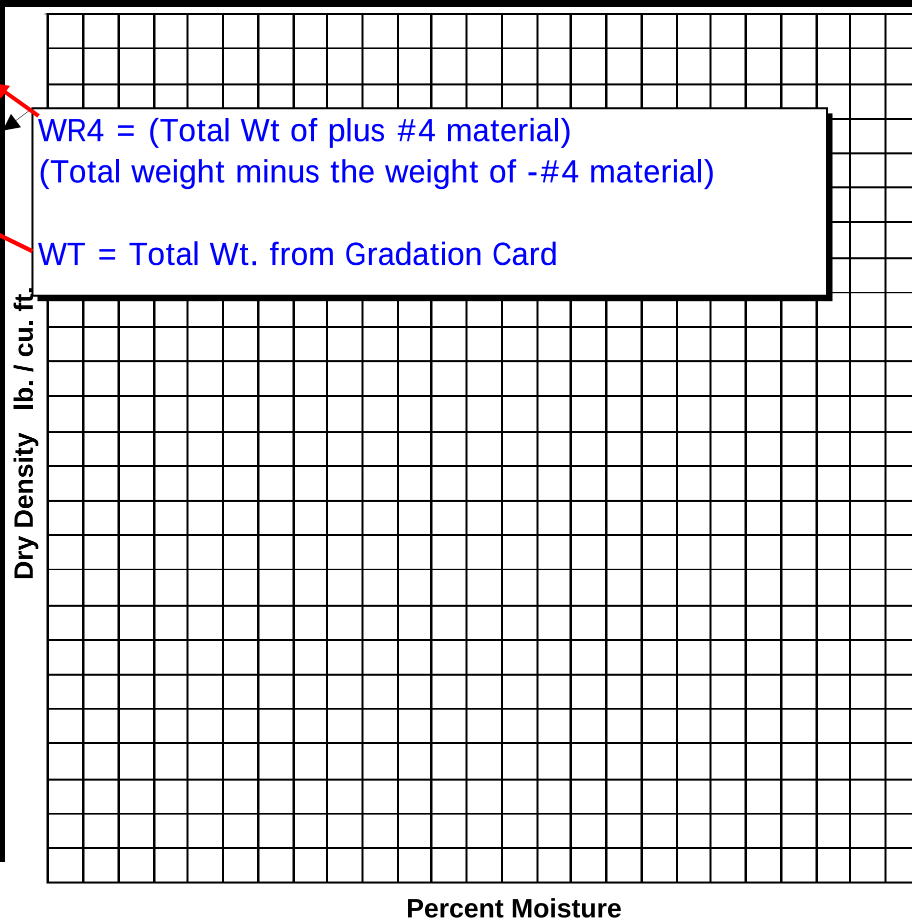
Coarse Aggregate Absorption : ______

OPTIMUM MOISTURE CONTENT = OM = ______ %

MAXIMUM DRY DENSITY (lb. / cu. ft.) = MD = ______ %

WR4 = (Total Wt of plus #4 material)
(Total weight minus the weight of -#4 material)

WT = Total Wt. from Gradation Card



Remarks : ______

Soils Review Class Calculations

Review Class Calculations

ARIZ 236 WORK CARD
DETERMINING pH AND MINIMUM RESISTIVITY
OF SOILS AND AGGREGATES

Lab Number: *Soils Review Class Calcs* **Date:** 02/01/2015

Project / TRACS #: ____________ **Tested By:** ____________

MINIMUM RESISTIVITY				
Range Setting		Dial Reading		Resistance, Ohms
10,000	X	8.2	=	
10,000	X	6.5	=	
10,000	X	2.7	=	
1,000	X	9.0	=	
1,000	X	1.5	=	
1,000	X	1.0	=	
100	X	3.5	=	
100	X	6.7	=	
	X		=	
	X		=	
	X		=	

pH

Sample Weight: 49.8 g **Water Weight:** ______ g

Start Time: 9:15
Stir ______
Stir ______
Stir ______
Stir ______
Stir ______
Stir ______
Stir ______
Stir ______
End Time: ______

Soil Box Factor = 6.71 cm **pH Reading =** ______ **pH =** ______

Buffers used for calibration of pH meter: ______

(Minimum Resistivity, Ohms-cm) = (Resistance, Ohms) x (Soil Box Factor, cm)

(________) X (________) = ____________ Ohms-cm

MINIMUM RESISTIVITY = __________ Ohms-cm

SOILS & AGG TECHNICIAN REVIEW TRAINING

Study Guide

Calculations Key

January 2016

Gradation Calculations for Review Class & Power Point

Rounded Coarse Sieve Factor (Six Places)

Coarse Agg Total

Un-rounded Coarse Sieve Factor

COARSE FACTOR

0.007800

100 / 12820 = 0.0078003120

Sieve	Wt. Retained	% RET.	% PASS			Wt. RET.		(Memory Recall) (MR)		
3"										
2 1/2"										
2"										
1 1/2"	0		100	100	-	319	x	*0.007800312*	=	97.5117004680
1"	319	2	98	97.5117004680	-	1194	x	*(MR)*	=	88.1981279251
3/4"	1194	10	88	88.1981279251	-	***1740***	x	*(MR)*	=	74.6255850234
1/2"	~~1736~~	13	75	74.6255850234	-	904	x	*(MR)*	=	67.5741029641
3/8"	904	7	68	67.5741029641	-	1002	x	*(MR)*	=	59.7581903276
1/4"	1002	8	60	59.7581903276	-	616	x	*(MR)*	=	54.9531981279
# 4	616	5								
- # 4	7045		55	-#4 Check =		7045	x	0.007800	=	*54.9531981279*
Total	12820									
1740	12816									

Revised 1/2" Wt.

Sum of weights

Rounded Fine Sieve Factor (Six Places)

Dry Wt. of -#4 Split

Un-rounded Fine Sieve Factor If -#4 material is Split.

DRY WT. OF- #4 SPLIT

558

FINE FACTOR

0.098566

55 / 558 = 0.098566308

Sieve	Wt. Retained	% RET.	% PASS							
				55	-	99	x	0.098566308	=	45.2419354839
# 8	99	10	45	45.2419354839	-	22	x	*(MR)*	=	43.0734767025
#10	22	2	43	43.0734767025	-	74	x	*(MR)*	=	35.7795698925
#16	74	7	36	35.7795698925	-	***111***	x	*(MR)*	=	24.8387096774
#30	~~113~~	11	25	24.8387096774	-	59	x	*(MR)*	=	19.0232974910
#40	59	6	19	19.0232974910	-	52	x	*(MR)*	=	13.8978494624
#50	52	5	14	13.8978494624	-	64	x	*(MR)*	=	7.5896057348
#100	64	6	8	7.5896057348	-	34	x	*(MR)*	=	4.23835125448
#200	34	4								
- # 200	6		4.2	-# 200 Check =		43	x	(MR)	=	*4.23835125448*
Total	521									
Elutriation	37									
111	523									

(Elutriation + - # 200's)

Sum of weights

Revised #30 Weight

ARIZONA DEPARTMENT OF TRANSPORTATION
SOIL AND AGGREGATE TABULATION

USE CAPITAL LETTERS

LAB NUMBER	ORG NUMBER	MATL	TYPE	PUR-POSE	TEST LAB	SIZE	SIZE %

TEST NO.	LOT OR SUFFIX	SAMPLED BY	MO	DAY	YEAR	TIME (MILITARY TIME)

SAMPLED FROM	LIFT NO.	RDWY	STATION (IF MILEPOST, INPUT DECIMAL)
			+

ORIGINAL SOURCE	PROJECT ENGINEER / SUPERVISOR	PROJECT NUMBER	TRACS NUMBER

REMARKS

Soils & Aggregate Review Class Calculations Key

CONTACT PHONE NO. - ( ) -

ARIZ 201
☐ Dried to Constant Wt.
☐ Not Dried to Constant Wt.

ARIZ 248
☐ Alt. 1 ☐ Alt. 2 ☐ Alt. 3
☐ Alt. 4 ☐ Alt. 5

% OVERSIZE: + 3 " ____ + 6 " ____

.007800312

COARSE FACTOR .007800 = 100 / COARSE SIEVE TOTAL

WET SAMPLE PREWEIGHT = ____
WET WT. OF - # 4 = ____
- # 4 SPLIT WET WT. = ____

		WEIGHTS RETAINED	% RET.	% PASS	SPECS.	CUMULATIVE % RET. FINENESS MODULUS
	3"					
	2 1/2"					
	2"					
	1 1/2"	0		100		
	1"	319	2	98		
	3/4"	1194	10	88		
1740	1/2"	~~173~~6	13	75		
	3/8"	904	7	68		
	1/4"	1002	8	60		
	# 4	616	5			
	- # 4	7045		55		
12816	Total	12820				

IF TOTAL SAMPLE IS WASHED:
UNWASHED WT. = ____
WASHED WT. = ____
ELUTRIATION = ____

DRY WT. OF - # 4 SPLIT: 558

.098566308

FINE FACTOR .098566 = % PASS # 4 / DRY WT. OF - # 4 SPLIT

		WEIGHTS RETAINED	% RET.	% PASS	SPECS.	
	#8	99	10	45		
	#10	22	2	43		
	#16	74	7	36		
111	#30	~~113~~	11	25		
	#40	59	6	19		
	#50	52	5	14		
	#100	64	6	8		
	#200	34	4			
	-#200	6		4.2		
523	Total	521 (Dry Weight)				
	Elutriation	37 = -#4 Split - Total Dry Weight				

FINENESS MODULUS = TOTAL CUMULATIVE % RET. / 100

T = AASHTO Tests

Test	Method	Result		SPECS.
Liquid Limit (LL)	T - 89			
Plastic Limit (PL)	T - 90			
Plasticity Index (PI) = LL - PL	T - 90			
Abrasion Method (A,B,C,D)	T - 96			
@ 100 Revolutions			%	%
@ 500 Revolutions			%	%
Absorption, H_2O	ARIZ 210 ARIZ 211		%	
Specific Gravity, SSD	ARIZ 210 ARIZ 211			
Specific Gravity, OD	ARIZ 210 ARIZ 211			
Specific Gravity, Apparent	ARIZ 210 ARIZ 211			
Proctor Method				A - ARIZ 225, C - ARIZ 226, D - ARIZ 226, AD - ARIZ 245, A1 - ARIZ 232, AD1 - ARIZ 246
Optimum Moisture			%	
Max. Dry Density			PCF	
Sand Equivalent	T - 176 ARIZ 242 (MAFC)			
At Least One Fractured Face	ARIZ 212		%	%
At Least Two Fractured Faces	ARIZ 212		%	%
Uncompacted Void Content	ARIZ 247		%	%
Moisture Content	T - 255 T - 265		%	
Flakiness Index	ARIZ 233		%	%
Carbonates	ARIZ 238		%	%
pH	ARIZ 236 OR 237			
Resistivity (ohm-cm)	ARIZ 236			
Soluable Salts (PPM)	ARIZ 237			
Unit Weight	T - 19		PCF	
Voids	T - 19		%	
Organic Imputities	T - 21			
Chloride Content (PPM)	ARIZ 736			
Sulfate Content (PPM)	ARIZ 733			
Exchangeable Sodium (%)	ARIZ 729			
Exchangeable Sodium (PPM)	ARIZ 729			

WHITE ☐
YELLOW ☐
BLUE ☐

RECEIVED DATE ____ TEST OPERATOR & DATE ____ SUPERVISOR & DATE ____

Specific Gravity and Absorption of Fine Aggregate (ARIZ 211)

Bulk Sp. Gr. (O.D. basis) $= \dfrac{A}{B + S - C}$

$$\frac{(\ 499.9\ )}{(\ 683.7\ ) + (\ 503.3\ ) - (\ 990.1\ )} = \frac{499.9}{196.9} = \mathbf{2.539}$$

2.538852

Where: A = mass of oven-dry sample in air, g. **499.9**

B = mass of pycnometer filled with water, g. **683.7**

C = mass of pycnometer with sample and water to calibration mark, g. **990.1**

S = mass of saturated-surface-dry sample, g. **503.3**

Bulk Sp. Gr. (SSD basis) = $= \dfrac{S}{B + S - C}$

$$\frac{(\ 503.3\ )}{(\ 683.7\ ) + (\ 503.3\ ) - (\ 990.1\ )} = \frac{503.3}{196.9} = \mathbf{2.556}$$

2.556120

Apparent Sp. Gr. $= \dfrac{A}{B + A - C}$

$$\frac{(\ 499.9\ )}{(\ 683.7\ ) + (\ 499.9\ ) - (\ 990.1\ )} = \frac{499.9}{193.5} = \mathbf{2.583}$$

2.583463

Absorption, percent $= \dfrac{S - A}{A} \times 100$

$$\frac{(\ 503.3\ ) - (\ 499.9\ )}{(\ 499.9\ )} = \frac{3.4}{499.9} \times 100 = \mathbf{0.68}\ \%$$

0.680136

Specific Gravity and Absorption of Coarse Aggregate (ARIZ 210)

Bulk Sp. Gr. (O.D. basis) $= \dfrac{A}{B - C}$

$$\frac{(\ 4197\ )}{(\ 4291\ ) - (\ 2610\ )} = \frac{4197}{1681} = \mathbf{2.497}$$

2.496728

Where: A = mass of oven-dry sample in air, g. **4197**

B = mass of saturated-surface-dry sample in air, g. **4291**

C = mass of saturated sample in water, g. **2610**

Bulk Sp. Gr. (SSD basis) = $= \dfrac{B}{B - C}$

$$\frac{(\ 4291\ )}{(\ 4291\ ) - (\ 2610\ )} = \frac{4291}{1681} = \mathbf{2.553}$$

2.552647

Apparent Sp. Gr. $= \dfrac{A}{A - C}$

$$\frac{(\ 4197\ )}{(\ 4197\ ) - (\ 2610\ )} = \frac{4197}{1587} = \mathbf{2.645}$$

2.644612

Absorption, percent $= \dfrac{B - A}{A} \times 100$

$$\frac{(\ 4291\ ) - (\ 4197\ )}{(\ 4197\ )} = \frac{94}{4197} \times 100 = \mathbf{2.24}\ \%$$

2.239695

Soils & Agg Review Class Calculations Key

Flakiness Index (ARIZ 233)								
Sieve Size	**1-1/2"**	**1"**	**3/4"**	**1/2"**	**3/8"**	**1/4"**	**# 4**	**# 8**
% Pass from Sieve Analysis			88	75				45
% Ret. From Sieve Analysis (**F**)			***10***	***13***				***10***
Weight of Test Sample			1610	1061				72
Weigh Passing Slot			258	173				12
***** Percent Passing Slot (**P**)			***16***	***16***				***17***
NOTE: Only the size fractions which have 10 or more percent retained are tesed for passing the appropriate slot, and used to determine the Flakiness Index by the eequation below.	* Percent Passing Slot (P) = $\dfrac{\textbf{Weight Passing Slot}}{\textbf{Weight of Test Sample}}$ **x 100**							

$$\text{FLAKINESS INDEX} = \frac{\{F\ (11/2")\ X\ P\ (11/2")\} + \ldots\ldots + \ldots\ldots + \{F\ (No.\ 8\ X\ P\ (No.\ 8)\}}{\{F\ (1\text{-}1/2")\ + \ldots\ldots + \ldots\ldots + \{F\ (No.\ 8)\}}$$

$$\text{FLAKINESS INDEX} = \frac{(\overset{\mathbf{160}}{10 \times 16}) + (\overset{\mathbf{208}}{13 \times 16}) + (\overset{\mathbf{170}}{10 \times 17}) = \mathbf{538}}{(10) + (13) + (10) = \mathbf{33}} = \frac{\mathbf{16}}{16.30303}\ \%$$

Fractured Particles (ARIZ 212)

At least one Fractured Face:

Wt. of test sample (Wa) $\frac{312}{376}$ **x 100** = = **376**

Wt. of fract. Particles(Wf) = **312**

Fract. Particles (FF) = $\frac{Wf}{Wa}$ **x 100** = ***83*** %

82.9787234

At least two Fractured Face:

Wt. of test sample (Wa) = NA

Wt. of fract. Particles(W_2) = NA

Fract. Particles (FF**2**) = $\frac{W\ 2}{Wa}$ x 100 = ______ %

$$\text{Moisture Content (T255, T265)} = \frac{\text{Wet Weight} - \text{Dry Weight}}{\text{Dry Weight}} \times 100 = \frac{(\ \mathbf{380.1}\ ) - (\ \mathbf{331.0}\ )}{(\ \mathbf{331.0}\ )} \times 100 = \frac{\mathbf{14.8}}{14.833837}\ \%$$

Soils & Agg Review Class Calculations Key

Sand Equivalent
AASHTO T176)
(ARIZ 242 FOR M.A.F.C)

Sand Reading	4.1
Clay Reading	5.5
Sand Equiv.	***75***
	74.55
Sand Reading	4.2
Clay Reading	5.5
Sand Equiv.	***77***
	76.36
Sand Reading	4.3
Clay Reading	5.7
Sand Equiv.	***76***
	75.44

$\frac{\text{Sand Reading}}{\text{Clay Reading}} \times 100$

Average Sand Equiv. = ***76***

76.00

Abrasion
AASHTO T96)

% Abrasion = $\frac{A - B}{A} \times 100$

Where: A = Original Mass (5000 ± 10 grams)

B = Plus # 12 Material after Abrasion

100 Rev.: ______ - ______ x 100 = ______ %

500 Rev.: ______ - ______ x 100 = ______ %

Type of Abrasion ______

Soils & Agg Review Class Calculations Key

Plasticity Index
(AASHTO T89 & 90)

Liquid Limit (LL) :

Bottle # **A** **Tare Wt. of Bottle:** **13.28** **# Blows** **25**

% Moisture =

$$\frac{\textbf{(Wet Wt. With Bottle) - (Dry Wt. With Bottle)}}{\textbf{(Dry Wt. With Bottle - Tare Wt. of Bottle)}} \times 100 =$$

(4.77 / 11.91) X 100 = 40.05037783

$$= \frac{(\ 29.96\ -\ 25.19\ )}{(\ 25.19\ -\ 13.28\ )}\ \frac{4.77}{11.91} \times 100 = \mathbf{40.1}\ \%$$

Liquid Limit = ***40*** (For 25 Blows)

Plastic Limit (PL) :

Bottle # **B** **Tare Wt. of Bottle:** **16.15**

$$\frac{\textbf{(Wet Wt. With Bottle) - (Dry Wt. With Bottle)}}{\textbf{(Dry Wt. With Bottle - Tare Wt. of Bottle)}} \times 100 =$$

(2.31 / 8.9) X 100 = 25.95505618

$$= \frac{(\ 27.36\ -\ 25.05\ )}{(\ 25.05\ -\ 16.15\ )}\ \frac{2.31}{8.9} \times 100 = \mathbf{26.0}\ \%$$

Plastic Limit = ***26***

Plasticity Index (PI) :

PI = (LL - PL) = (**40**) - (**26**) = ***14***

AASHTO T19
UNIT WEIGHT AND VOIDS IN AGGREGATE

Date of Calibration: *Soils Review Class Calculations* *Key* Test Operator: ______

Measure Identification: 1 (1/4 lb/ft³)

Mass of Glass Plate: **0.2** **LB.**

C = Mass of Measure and Glass Plate: **8.3** **LB.**

B = Mass of measure filled with Water and Glass Plate: **23.8** **LB.**

Mass of Water used to fill Measure: ***15.5*** **LB.**

Temperature of Water: **67** ° F **D** = Density of Water from Table 3 = ***62.322*** lb/ft³

$$\mathbf{V} = \text{Volume of Measure} = \left[\frac{(B - C)}{D}\right] = \qquad \mathbf{V} = \frac{(23.8) - (8.3)}{(62.322)} = \mathbf{0.2487}\ \text{ft}^3$$

0.2487083

Procedure (check one): [x] Rodding [ ] Jigging [ ] Shoveling

T = (8.3 - 0.2) = *8.1*

62.336 - 62.301= 0.035
70 - 65 = 5
0.035 / 5 =0.007
0.007 x 2 = 0.014
62.336 - 0.014 = 62.322

Mass of Measure, **T** = ***8.1***

Mass of Measure and Aggregate, **G** = **27.2** LB.

Table 3		Density of Water	
Temperature			
°C	°F	Kg/m³	Lb/ft³
15.6	60	999	62.366
18.3	65	998.5	62.336
21.1	70	998	62.301
(23.0)	(73.4)	(997.54)	(62.274)
23.9	75	997.3	62.261
26.7	80	996.6	62.216
29.4	85	995.8	62.166

Unit Weight (Oven Dry) of Aggregate, **M = (G - T) / V**

19.1/ 0.2487= ***76.79935665***

$$\mathbf{M} = \frac{(27.2 - 8.1)}{(0.2487)} = \mathbf{77}\ \text{lb/ft}^3$$

76.7994

Unit Weight (SSD) of Aggregate, M_{SSD} = $\mathbf{M} \times \left(1 + \frac{A}{100}\right)$

(2.24 / 100) + 1 = ***1.0224***

Where A = Percent Absorption from ARIZ 210 test method. ***1.0224***

77 x 1.0224 = ***78.72480***

$$\mathbf{M_{SSD}} = (77) \times \left[1 + \frac{2.24}{100}\right] = \mathbf{79}\ \text{lb/ft}^3$$

78.72480

Void Content = $\dfrac{100 \times [(S \times W) - M]}{(S) \times (W)}$

Where S = Bulk Specific Gravity (oven dry) from ARIZ 210 test method

Where W = **62.3** lb/ft³ (Density of Water)

(2.497 x 62.3)= ***155.5631***
155.5631 -77 = ***78.5631***
78.5631 x 100 = ***7856.31***

7856.31

$$\textbf{Void Content} = \frac{100 \times [(2.497) \times (62.3) - (77)]}{(2.497) \times (62.3)} = \mathbf{51}\ \%$$

155.5631

50.50240063

7856.31 / 155.5631 = ***50.50240063***

ADOT Intermodal Transportation

ARIZONA DEPARTMENT OF TRANSPORTATION

CALIBRATION OF PROCTOR MOLD
ARIZ 225 Appendix A

✓ Four Inch Mold ______ Six Inch Mold Mold I. D. #: 4A

Calibration Date: 12/01/15 Calibration Expiration Date: 12/01/15

Temperature of water used for Calibration: 73 ° F

Unit Weight of Water: 62.277 lb. /cu. ft.

Test Operator: Joe Tester Supervisor and Date: Joe Supervisor 12/01/15

Weight of Baseplate, Empty Mold, and Glass Plate (grams)	Weight of Baseplate, Mold Filled with Water, and Glass Plate (grams)	Weight of Water to Fill Mold (grams)
4526.7	5465.5	938.8

$$V = \begin{bmatrix}\textbf{Volume of} \\ \textbf{Mold} \\ \textbf{(cu. ft.)}\end{bmatrix} = \frac{\textbf{Weight of Water to Fill Mold (grams)}}{\begin{bmatrix}\textbf{Unit Weight} \\ \textbf{of Water} \\ \textbf{(lb. / cu. ft.}\end{bmatrix} \textbf{ X } [\textbf{453.6 (grams / lb.)}]}$$

$$V = \frac{(\quad 938.8 \quad)}{(\quad 62.277 \quad) \text{ X } (\quad 453.6 \quad)} = \frac{0.0332}{\mathit{0.033233215}} \text{ cu. ft.}$$

REMARKS: ______

Unit Weight of Water Table

Temp °F	lbs/cu. Ft.	Temp °F	lbs/cu. Ft.
68	62.315	77	62.243
69	62.308	78	62.234
70	62.301	79	62.225
71	62.293	80	62.216
72	62.285	81	62.206
73	62.277	82	62.196
74	62.269	83	62.186
75	62.261	84	62.176
76	62.252	85	62.166
		86	62.155

Arizona Department of Transportation

METHOD A or **ALTERNATE METHOD D** PROCTOR DENSITY

(Arizona Test Method 225 or 245)

Project No: S & A Study Guide Calculations Key Lab No : ________ Rec'd Date: ________

Source and Type of Material : ________

Proctor Method Used : **Method A** ✓ or **Alternate Method D** ________

Test Operator and Date : ________ Supervisor and Date: ________

Weight of Mold = **M2** =	**2036** grams	Volume of Mold = **VM** =	**0.0332** cu ft	**a** = VM x 453.6 =	**15.0595**

b	M1	c	WD	ED	WW	DW	d	e	DD
					Moisture Determination				
Approx % of water Added	Wt. of Sample and Mold	Wet Wt. of Sample M1 - M2	Wet Density lb/ cu ft c / a	Est. Dry Density WD x 100 / b + 100	Wet Wt. of Moisture Sample	Dry Wt. of Moisture Sample	Wt. of Water WW - DW	Percent Moisture d x 100 / DW	Dry Density lb/cu ft WD x 100 / e + 100
6	3890	*1854*	*123.1*	*116.1*	302.4	285.2	*17.2*	*6.0*	*116.1*
8	4002	*1966*	*130.5*	*120.8*	311.4	287.6	*23.8*	*8.3*	*120.5*
10	4079	*2043*	*135.7*	*123.4*	315.4	285.0	*30.4*	*10.7*	*122.6*
12	4066	*2030*	*134.8*	*120.4*	312.5	278.4	*34.1*	*12.2*	*120.1*

METHOD A

WT = **12820** WR4 ***5775***

7045 = Total - #4 material

PR4 = WR4 / WT x 100 = ***45%***

45.04680187

ALTERNATE METHOD D

WT = **N/A** WR 3/4 **N/A**

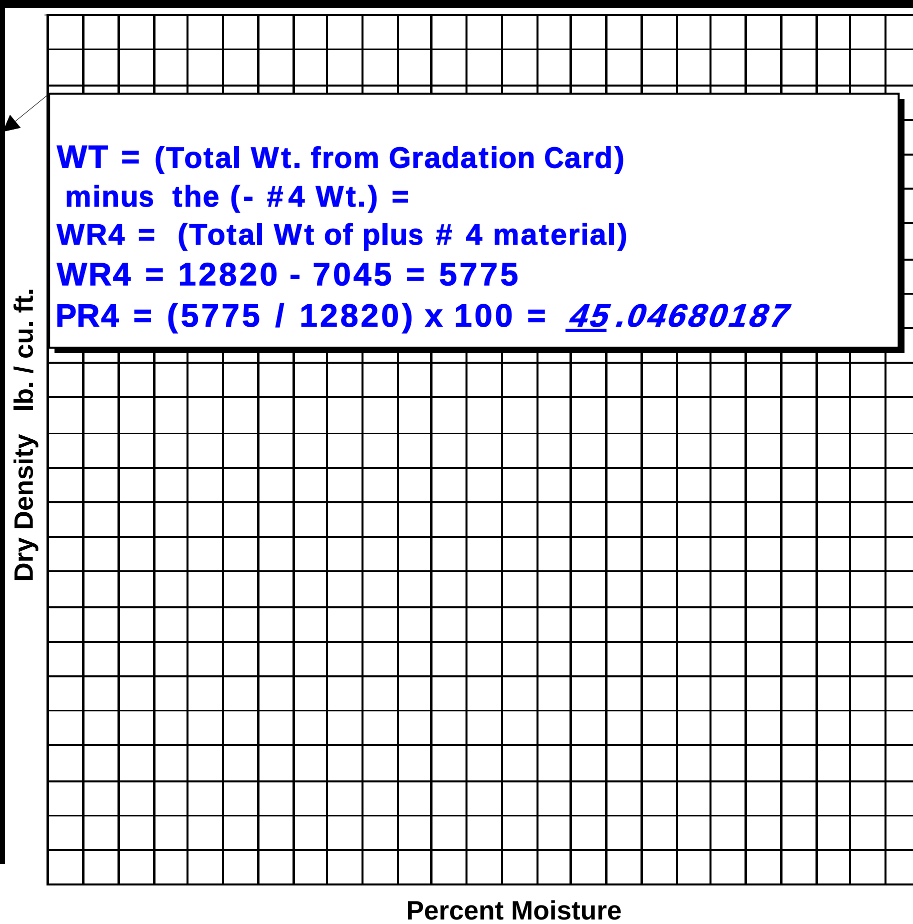
PR 3/4 = WR 3/4 / WT x 100 = ____ %

Coarse Aggregate Bulk Oven Dry Specific Gravity : ________

Coarse Aggregate Absorption : ________

OPTIMUM MOISTURE CONTENT = OM = ***10.0*** %

MAXIMUM DRY DENSITY (lb. / cu. ft.) = MD = ***123.8***



WT = (Total Wt. from Gradation Card) minus the (- #4 Wt.) =

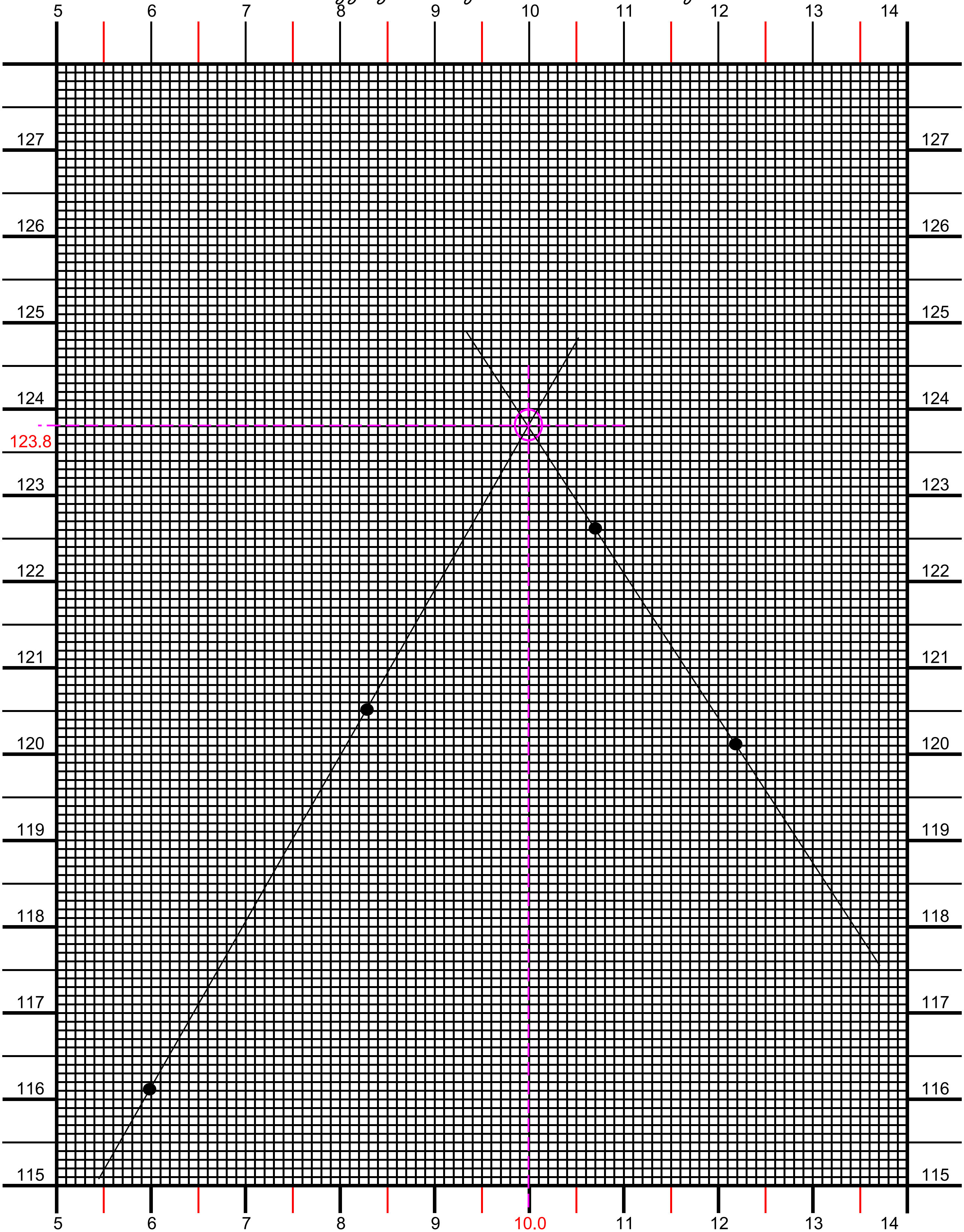
WR4 = (Total Wt of plus # 4 material)

WR4 = 12820 - 7045 = 5775

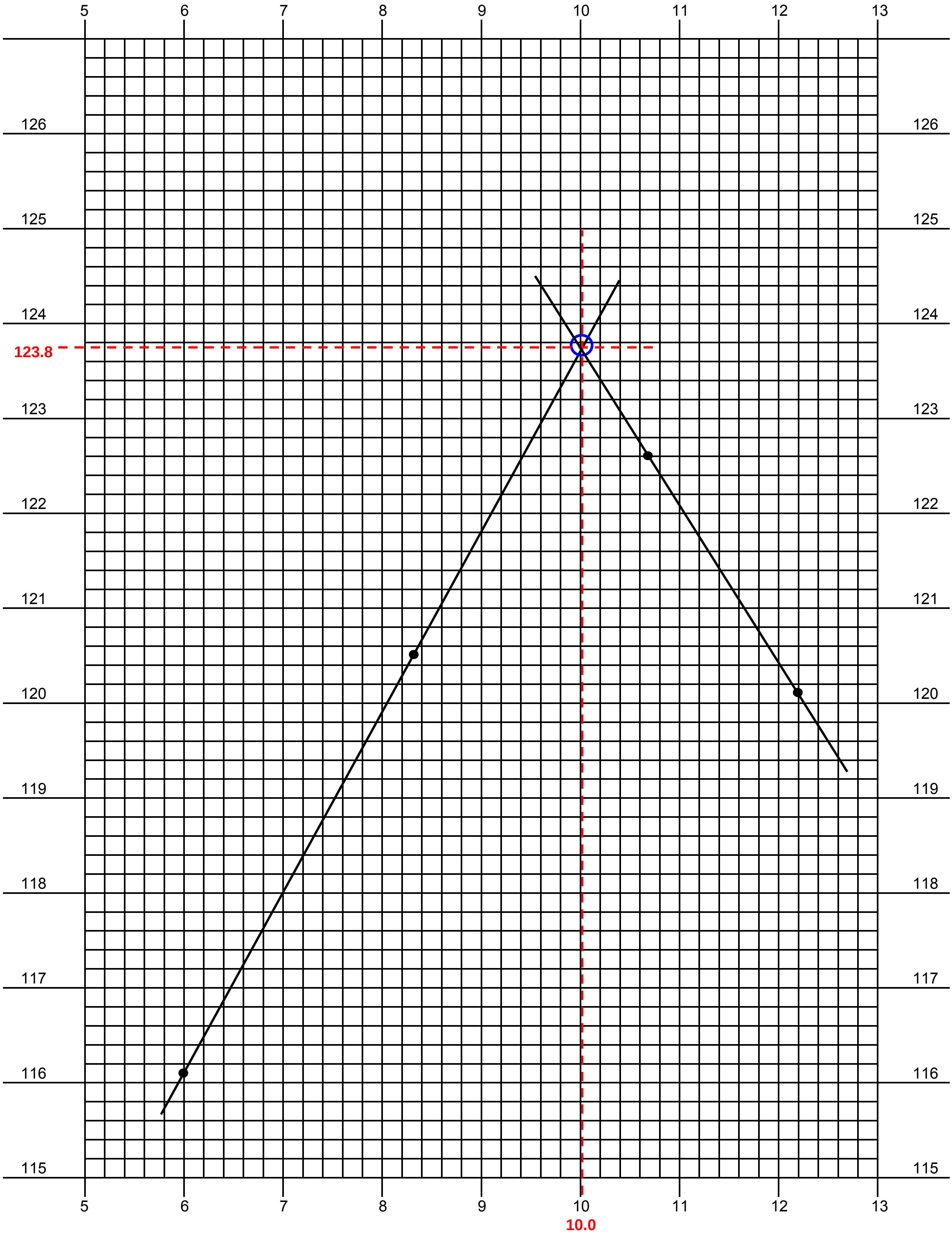
PR4 = (5775 / 12820) x 100 = *45.04680187*

Remarks : ________

Soils Aggregate Study Guide Calculations Key



Soils Aggregate Study Guide Calculations



ARIZ 236 WORK CARD
DETERMINING pH AND MINIMUM RESISTIVITY OF SOILS AND AGGREGATES

Lab Number: *Soils Review Class Calcs* *Key* **Date:** 02/01/2015

Project / TRACS #: ______ **Tested By:** ______

MINIMUM RESISTIVITY

Range Setting		Dial Reading		Resistance, Ohms
10,000	X	8.2	=	82,000
10,000	X	6.5	=	65,000
10,000	X	2.7	=	27,000
1,000	X	9.0	=	9,000
1,000	X	1.5	=	1,500
1,000	X	1.0	=	1,000
100	X	3.5	=	$\boxed{350}$
100	X	6.7	=	670
	X		=	
	X		=	
	X		=	

pH

Sample Weight: 49.8 g **Water Weight:** *49.8* g

Start Time: 9:15

Stir *9:25*

Stir *9:35*

Stir *9:45*

Stir *9:55*

Stir *10:05*

Stir *10:15*

Stir ______

Stir ______

End Time: *10:15*

Soil Box Factor = 6.71 cm

pH Reading = 7.86 **pH =** *7.9*

Buffers used for calibration of pH meter: 7 & 10

(Minimum Resistivity, Ohms-cm) = (Resistance, Ohms) x (Soil Box Factor, cm)

(*350*) X (*6.71*) = *2348.5* **Ohms-cm** (un-rounded)

MINIMUM RESISTIVITY = *2349* Ohms-cm